

SAPINDALES

STEVENS *loc. cit.* counts the diversity of Sapindales as nine families, 460 genera and 5670 species. Within tropical Asia, the Sapindales include nearly 100 genera and 800 species, many are abundant, and many are economically important. Collectively they make up a key part of the main canopy of the lowland forest. Timber is taken especially from the Burseraceae and some Meliaceae. The order also includes most of our important fruit trees: mangoes (Anacardiaceae), santol and langsat (Meliaceae), rambutans and longans (Sapindaceae), and citrus (Rutaceae). As a reading of that list suggests, the Sapindales are pungent and resinous trees that continue to provide new medicines, gums, resins and essential oils.

The order is monophyletic¹. The traditionally close relationship between Anacardiaceae and the Burseraceae is substantiated by molecular evidence, as is a similar link among the Meliaceae, Rutaceae and Simaroubaceae. The branching order within the family is otherwise unclear.

The order was once known by the name Pinnatae in reference to the common feature of dense upturned clusters of feathery pinnately compound leaves. Indeed, the only large trees of the Asian tropics with pinnately compound leaves that are not in the order are the Bignoniaceae (of seasonal dry lands, leaves opposite) and the Fabaceae (usually with true stipules, many with a bean odor).

The floral form is likewise fairly uniform within the order. The flower is usually small, less than one cm across with a well developed disc, the parts in fives or threes, the gynoecium with only a few ovules per carpel. Unisexual flowers are common, and staminate and carpellate

flowers have well-developed pistillodes and staminodes respectively. When the flowers are bisexual, functional unisexuality is often suspected.

In the Anacardiaceae and Burseraceae, the inflorescence is typically a great branched pyramid that terminates the larger twigs; new growth arises from below the leaves. Cauliflory is not known among that family pair, at least within our region. In the Meliaceae and allies, the flowers tend to be from smaller panicles and racemes, these from among the lower leaves; in *Chisocheton* and *Dysoxylum*, cauliflory is not uncommon. New growth arises from branches at the axils of the upper leaves.

All of the large families are predominantly tropical in distribution and primarily of the lowland tropics; they are poorly represented in the northern latitudes and also poor in the tropics above 1000 m elevation. *Acer* and allies in the Sapindaceae are the most notable exceptions.

The order shows a strong tendency toward a deciduous habit, even within the everwet equatorial lowlands; this may suggest an ancestry in dry seasonal climates. In this regard we might note that each of the large families of trees appears to divide somewhat imperfectly along cladistic lines between a component of trees that are most common in the dry-seasonal forest and a component of trees most prevalent in the lowland everwet forests. The contrast in the Anacardiaceae is between the mangoes in the everwet lowlands and the *Spondias* types in dry seasonal forests; in the Burseraceae, between the *Canarium* type and the *Garuga* type (and *Commiphora* of India); in the Meliaceae, the *Aglaia* type and the *Swietenia-Toona* type; and in the Sapindaceae, between the rambutans and the dry-fruited types. In this contrast we see the outlines of a yet untold story that combines ecology, geography and phylogeny.

Phylogeny of Sapindales

	Family	Diversity & Distribution	Trees of Tropical Asia
	Bierbersteiniaceae	1/5, central Asia, 2-3 compound	0
	Nitrariaceae	3/16, arid N Africa, Asia, Australia	0
	Kirkiaceae	2/6, trees E Africa, Madagascar	0
	Burseraceae	20/550, pantropical, trees with compound leaves.	8/150, species-rich and abundant both locally and regionally.
	Anacardiaceae	70/600, pantropical, trees and lianas, simple or compound leaves	21/250-300, with either compound or simple leaves, species-rich and abundant, locally and regionally.
	Sapindaceae	135(?) /1580, global,	41/200, species-rich and abundant.
	Simaroubaceae	19/95, pantropical,	A minor component, a few larger trees in gaps or in dry seasonal lands; <i>Eurycoma</i> in the understory of Sundaic Region.
	Meliaceae	51/565, pantropical,	19/250, species-rich and abundant.
	Rutaceae	161/1850, pantropical and subtropical, especially Asia.	27/100, but a minor component, of small stature, most common in dry seasonal and subtropical lands.

¹Muellner, A. *et al.* 2007. Plant Systematics and Evolution. 266: 233–252.

BURSERACEAE

NAME: From the genus *Bursera*, Greek for purse, in reference to the dry pouch of the fruit in that genus. The Malay name *kedondong* applies to the timber and is widely used for almost all members of the *Canarium*-group; the Iban name *seladah* is used in similar fashion in Borneo, whereas in the Philippines we might call it the *pili*-nut or *kenari*-nut family. In English, this is often as the frankincense family, in reference to the resin used for incense since biblical times.

OVERVIEW: The Burseraceae are a critically important family of trees throughout the tropical world, represented by maybe 700 species in 20 genera. Within the region we have eight genera (nine, if we include the monotypic *Rosselia* of Rossel Island off the coast of New Guinea) and about 150 species. The center might be reckoned in Borneo with eight genera and about 60 species. The family is abundant in both lowland equatorial everwet forests and also in the seasonally dry forests, although with a different generic and species composition in each.

Molecular evidence indicates that the family is monophyletic and sister to the Anacardiaceae^{1,2,3}. Those species of the latter that bear compound leaves can look like some Burseraceae, and they do share a resinous body, and in some species a white or clear exudate and large pyramidal inflorescences of small flowers. They differ in that resins of Burseraceae never turn black, are non-allergenic and usually smell strongly of turpentine (the dry resin is fragrant and incense-like when burnt), and bear two epitropous ovules (vs. one apotropous) per carpel. The abundant members of the *Canarium*-group also differ from Anacardiaceae in that the leaflet stalks are swollen on both ends.

The Burseraceae are typically main canopy trees, less commonly of small stature, but always resinous, and bear spirally arranged compound leaves, the leaflets opposite with a terminal leaflet. Most often, the leaflets are borne by double swollen stalks; the leaf in *Canarium* bears stipule-like organs, variously formed as awls, kidney-shaped or otherwise, these usually interpreted as the reduced product of the lowermost leaflets.

As in the sister family Anacardiaceae, these trees have large pyramidal inflorescences of small flowers, regular, three- or five-parted, with a spreading corolla, the stamens either equal to or double the number of the perianth parts, and embedded in the disc or outside at its base.

The flowers are mostly small (less than five mm across) unisexual, (the trees dioecious), parts in fives or threes, the sepals are partly fused, the petals free and spreading, the stamens introrse, often twice the petal number and

adnate to a disc, the anthers with longitudinal slits; and staminodes typical in female flowers. The superior gynoecium is mostly three carpelate, forming a three-locular ovary with terminal style, maturing as a thinly fleshy drupe about 1–3 cm long with a single stone bearing one (or more) seeds, (or in *Protium* and relatives, the fruit with two to five stony parts that may be free or touching but not fused). Among our trees, only *Triomma* bears a winged dehiscent capsule with three one-seeded winged nutlets, a feature more common in Africa and America.

Within the *Canarium*-Group, vegetative characters are not diagnostic for genera, but it is not difficult to recognize many of the common individual species because they tend to be widespread, abundant and uniform. Features that vary among species include most details of the leaf: the number of leaflets, the indumentum, the toothed margin, the presence of stipules. The presence of white or clear resin varies with species, some have only a slow flowing resin that can be seen hardened on the bark, others like the very common *Dacryodes rostrata* have copious and free-flowing white sap.

Within the lowland equatorial forests, the Burseraceae are always among the three or four dominant families of big trees, represented by a dozen or more species. Diversity and abundance drop rapidly with elevation (21 species recorded for Mt. Kinabalu, but fewer than half reach 1000 m). They are not typically riparian nor littoral nor, in general, of secondary forests. The many species of the family are distributed with notable evenness within the constituent regions of tropical Asia. For example, of the 50 or so species of Burseraceae in Borneo (excluding the

FIELD RECOGNITION

Main canopy trees, or lower canopy, rarely as small trees; those of the largest diameters with well-developed plank buttresses.

Always with a large compound leaf, strictly opposite leaflets and a terminal leaflet.

Bark is smooth, light gray or tan-brown becoming flaky in the larger trees, sometimes cracking in large plates, but never deeply furrowed or fissured.

Pinnately compound leaves arranged in loose clusters.

The entire plant body is resinous, especially the twigs, often with a clear or milky-white exudate smelling strongly of turpentine, highly variable in extent.

The leaflet stalk is swollen at both the junctions of leaflet and leaf stalk; exceptions are *Garuga* and *Triomma*; a few species of *Canarium* and *Santiria* bear nearly sessile leaflets.

FIELD CONFUSION

The double swollen leaflet stalk is found in *Walsura* (Meliaceae) but that tree lacks a turpentine odor, and the lower surface of the leaflet is pale, glaucous, and finely veined

Anacardiaceae with compound leaves can be confused with Burseraceae, especially in America and Africa, but once you know *Triomma* and *Garuga* such confusion is not likely in Asia where the Burseraceae are dominated by the distinctive *Canarium* Group. The fruit of some *Canarium* are soft and pulpy like a mango and both have a similar turpentine odor, but *Canarium* has a triangular pyrene, not a flattened fibrous endocarp.

¹Weeks, A. et al. 2005. Molecular Phylogenetics and Evolution. 35: 85–101.

²Becerra, J. et al. 1999. American Journal of Botany. 86: 1047–1057.

³Thulin, M. et al. 2008. Nordic Journal of Botany. 26: 218–229.

Phylogeny of Burseraceae

All 20 genera of Burseraceae as currently recognized, the clustering follows Weeks (2005) and Thulin (2008) as cited in the introduction. Asterisks indicate genera that have not been sampled for molecular data. *Scutinanthe* in particular is of uncertain placement. Genera with problems of delimitation include *Bursera* and *Commiphora*; in *Dacryodes*, the American species may be a clade distinct from the Asian species; *Santiria* is variable and the small genera may be nested within.

	Genus	Diversity, Distribution, Notes	Trees of Tropical Asia
	<i>Bieselia</i>	1, Mexico.	0
	<i>Aucoumea</i>	1 W Africa, dry fruit, winged stone.	0
	<i>Bursera</i>	100, Neotropics, fleshy fruit, aril.	0
	<i>Commiphora</i>	190, Africa, India, Neotropics.	0
	<i>Boswellia</i>	30, Africa, India.	0
	<i>Garuga</i>	4, India and dry-seasonal tropical Asia, unswollen leaflet stalk, stipels, ragged toothed leaflet margin.	4
	<i>Ambilobea</i>	1, Madagascar.	0
	<i>Canarium</i>	100, Africa, S China, tropical Asia to Australia, toothed leaflet and/or stipule, rarely neither.	60
	<i>Canariellum</i>	5, Australia to New Caledonia.	0
	<i>Dacryodes</i>	66, pantropical (different clades?), most species-rich and abundant in equatorial Asia, no stipule, no teeth, apical stigma, wrinkled dry fruit.	50
	<i>Pseudodacryodes</i> *	1, African.	0
	<i>Santiria</i>	24, Africa, equatorial Asia, no stipule, no teeth, lateral stigma, smooth dry fruit.	20
	<i>Rosselia</i> *	1, Rossel Island, New Guinea.	0
	<i>Haplolobus</i> *	22, New Guinea, west to Borneo; apical stigma, smooth dry fruit.	3
	<i>Trattinnickia</i>	13, Neotropics.	0
?	<i>Scutinanthe</i> *	2, Sri Lanka, Sundaic Region, sunken midrib, flower 5-merous,	1
?	<i>Triomma</i>	1, Sundaic Region, unswollen leaf stalk, asymmetric leaflet base, dry triangular capsule, winged seeds.	1
	<i>Protium</i>	150, pantropical, chiefly Neotropics, about 4 in Asian dry forests; double-swollen leaflet stalk, margin often toothed, no stipule, flower 5-merous.	4
	<i>Crepidosperrum</i>	6, Neotropics.	0
	<i>Tetragastris</i>	9, Neotropics.	0

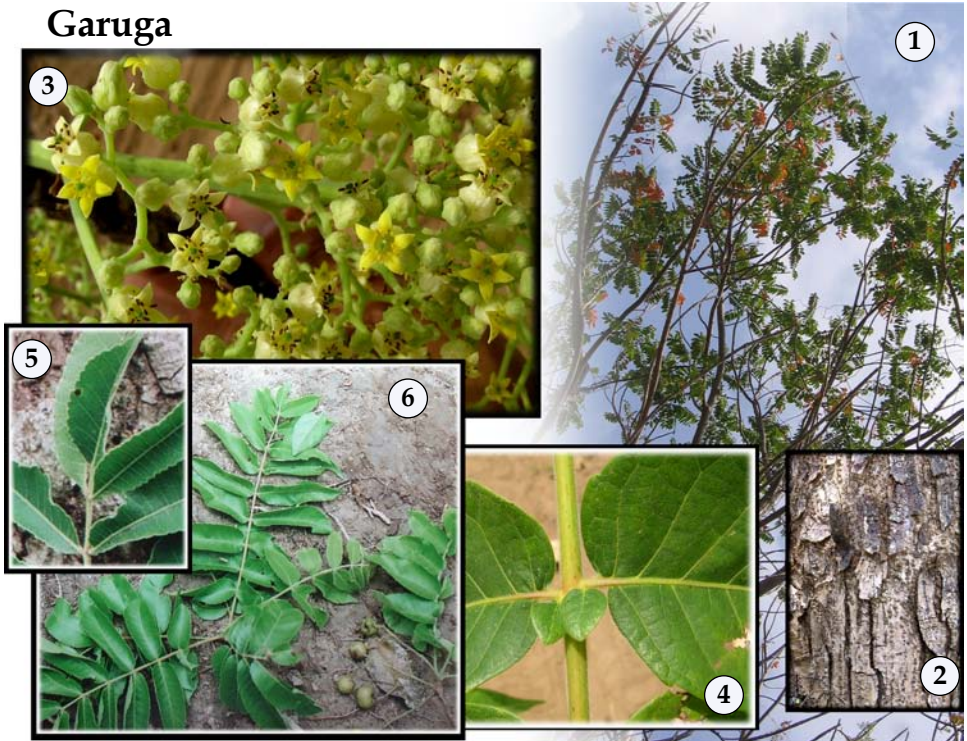
uncertain *Haplolobus*) 39 are documented for the 52-ha plot at Lambir, Sarawak.

Considering the distribution more broadly, the Burseraceae show a pattern that parallels to some extent the pattern found in the sister-family Anacardiaceae. The *Canarium*-group is centered in richness and abundance in the lowland equatorial forests of Malaya and Borneo whereas the more distantly related genera of *Protium* and *Garuga* are found most abundantly in the strongly dry-seasonal lands on the Asian mainland, eastern Borneo and along the west coast of the Philippines. However, unlike the Borneo-centric *Anacardium*-group which shows little northward penetration into the Philippines, all three main Bornean genera of the Burseraceae (*Canarium*, *Santiria* and *Dacryodes*) extend as far north as Luzon, while contrariwise, only *Canarium* reaches southern China on the mainland and represented there by species different from those of Malaya.

The family has been plagued by over description at the species level, which is somewhat surprising in that most of the species of the Sundaic Region tend to be clear. However, MERRILL *loc. cit.* credited the Philippines Islands with 46 species of *Canarium*, most of them known from single locations and often from single collections. There are now about nine recognized species. A student should bear in mind that while Merrill might be excused on the necessity of making an initial survey, the description of a new species from a family such as Burseraceae should today include descriptions of both staminate and pistillate flowers as well as fruit and some indication of variation. The addition of numerous new species of *Haplolobus* in Borneo based on a handful of specimens is excessive. The situation also reflects the continuing need for field study of species-level biology.

Less is known of the natural reproductive ecology of Burseraceae than is known of the related Anacards. Most of the canopy trees are dioecious and day-flow-

Garuga



Garuga. 1-4, *G. floribunda*. Bataan, Philippines; 1, canopy of tree, rosettes of pinnately compound leaves, deciduous; 2, bark, black thickly flakey and lenticulate; 3, flowers, bisexual, 5-merous; 4, leaflet base with stipule-like growths; 5-6, in Thailand; 5, the leaflets; 6, fleshy fruit with 1-5 pyrenes. (Photographs 1-4, © Ulysses Ferreras.)

ering. Dispersal is by birds and primates, perhaps secondarily by ground mammals; only the odd *Triomma malaccensis* bears a dry dehiscent capsule and three thinly winged seeds.

GARUGA. [From a vernacular name]. A genus of four species from India and China to Australia, generally found only in places with a strong dry season. It is uncommon in the Sundaic Region, but well-known in Mainland SE Asia and in the Philippines. In the latter, it is called by the Tagalog *bogo*.

Garuga is an unusual Burseraceae of uncertain phylogenetic placement. It is recognized as a small to medium tree with a resinous body and completely deciduous habit, soft sessile leaflets with ragged toothed margins and simple leaflet stalks. Some species bear small stipel-like organs at the base of the leaflets. Unlike most members of the family, the flowers are bisexual. The parts in fives, sepals nearly free and valvate, stamens 10 from the margin of disc. The ovary is five-celled while the mature

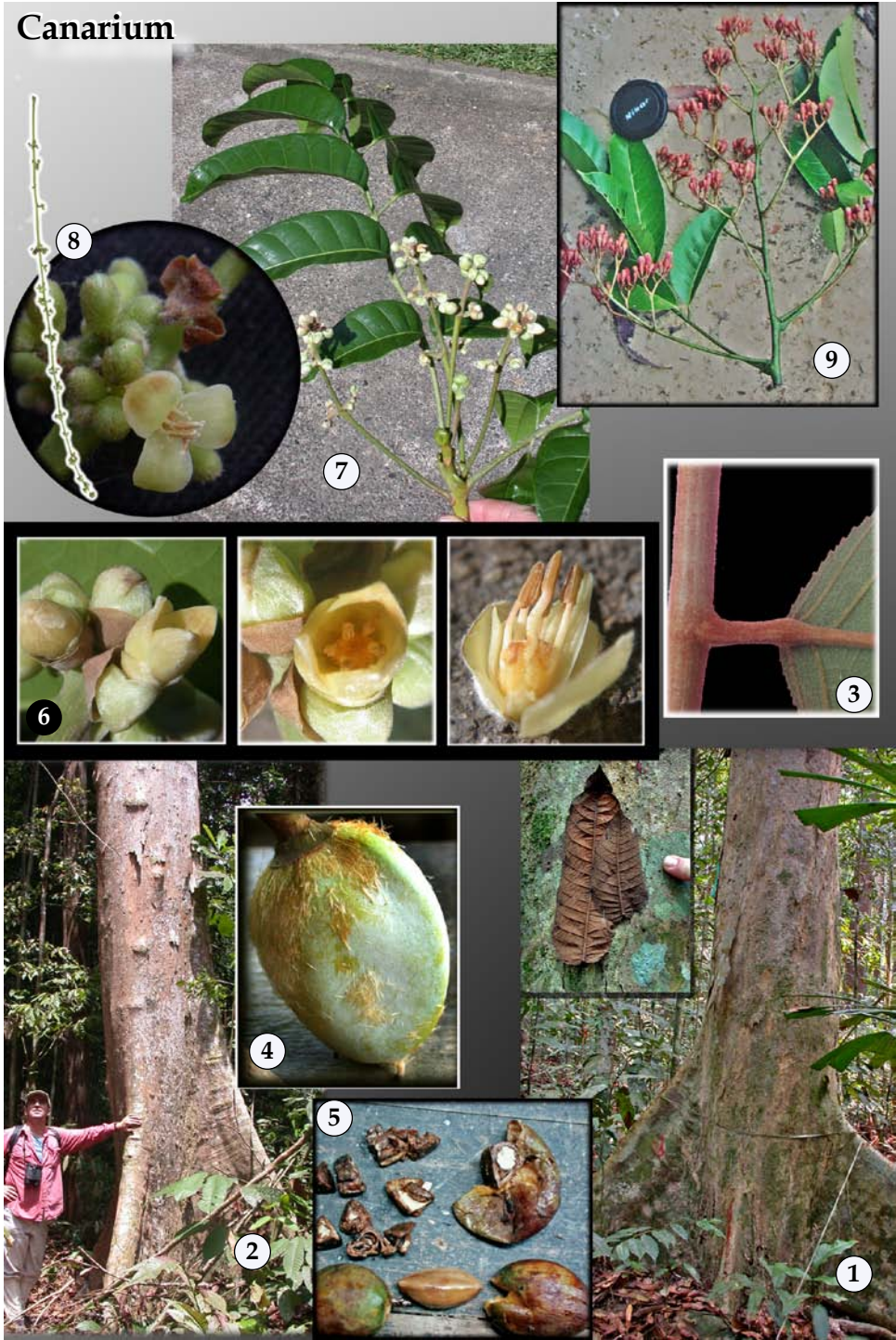
drupe is globose with a fleshy exocarp and one to five bony grooved pyrenes.

Garuga comprises two rare species in China and two common species found widely in the region: *G. pinnata* with flowers about 10 mm across, a fast-growing tree easily propagated from big branches, from India to Philippines; and *G. floribunda* with flowers less than five mm across, India to Australia.

CANARIUM. [Latinized form of *kenari*, the Moluccan name for the *kenari*-nut tree.] Maybe 75 species, Africa to Pacific. In tropical Asia, we find about 50 species, some widespread species especially in the Sundaic Region, but generally, the species divide between those of the dry-seasonal forests of Mainland SE Asia, species of the everwet Sundaic Region and species of the eastern part of tropical Asia. For example, of the seven species recorded for southernmost China none reach even so

⁴Weeks, A. 2009. Genetic Resources and Crop Evolution. 56: 765-781.

Plate on next page: *Canarium*. 1, *C. rufum*, a typical mature tree with gray bark and low plank buttresses, inset of the fallen leaves with sharply serrate margins; 2, *C. megalanthum*, the bark flakes in large plates; 3, the leaflet stalk in *Canarium* is short or long, but usually double swollen, the leaf margin often with sharp serration, *C. tomentosum*; 4-5, the fruit is typically a pointed elongate drupe with a 3-sided single-seeded pyrene, these often broken open by ground mammals, 4, *C. hirsutum*; 5, *C. littorale*; 6-7, *C. ovatum*; 6, the flower,



small and with the 3-part corolla typical of the family, 7, the inflorescence; here an open branched axillary panicle; 9, a *Canarium* at Lambir, Sarawak, with awl-shaped stipules and red flowers. (Photograph 4, © Leonardo L. Co.)

Canarium



Canarium stipules. These organs, while called stipules, are associated with the leaves more than with the node. The form varies greatly among species, in ways that may reflect relationships. From left to right, *C. rufum*, large leafy stipules with wavy margins; *C. denticulata*, with peculiar stipules, deeply cut and sculptured; *C. pilosum*, with single awl-like stipules; 4, *C. ovatum*, with blunt lobed stipules high on the rachis at maturity, but joined by shiny resin in bud.

far south as Peninsular Thailand. Preliminary molecular studies indicate that if the genus *Canariellum* were resurrected to accommodate all species of *Canarium* section *Canariellum* except *C. whitei*, then *Canarium* would be strongly monophyletic⁴. Among the relatives in the Burseraceae, *Canarium* is distinguished by the odd 'stipules' at the leaf base in combination with the toothed margin, and by the three-locular ovary with a terminal stigma that usually develops as a three-sided fruit with a single-seeded pyrene.

These are mostly large evergreen trees, without copious exudate from the twigs and trunk, although turpentine-smelling resin is common, and the fruit of some species, such as *C. megalanthum*, bear fruit full of white latex. The stipules vary widely in form from broadly kidney shaped, deeply fringed and palmate or simple awl-shaped, and they are diagnostic to species. A few species, such as *C. patentinervium*, have neither stipules nor a toothed leaflet margin, and these can be difficult to distinguish in the field from *Dacryodes*.

The flowers are ordinary for the *Canarium* Group: unisexual-dioecious, the calyx cup-shaped with three small lobes, the three petals strongly overlapping, variously colored by species, sometimes spreading with exposed anther (in the male flowers) or sometimes with a small opening. The genus is said to differs from other genera in that there is an axial intrusion conspicuous in the fruit and lids cover the pyrenes.

There remain many species-level problems in the genus. Of particular note is the suite of related species *C. littorale*, *C. rufum*, *C. tomentosum*, and *C. purpuaceum*, often described as varieties or forms of the first species. What is odd is that these closely related types are perfectly distinct within any particular forest - and they often do occur in sympatry - and yet they intergrade at the regional level.

The kernel from the fruit of several species is a valued nut in much of tropical Asia, especially *C. ovatum* and *C. luzonicum*, the *pili* nut of the Philippines, and *C. harveyi* of the Solomon Islands, and the *kenari* nut itself,

C. indicum. Some may find the hint of turpentine objectionable, but it is no more so than in pine nuts. They make up a significant commerce in the Philippines, but have so far failed to develop an international market.

DACRYODES. [Greek for teardrop, in reference to characteristic drops of hardened resin on the bark.] 80 species of the Asian and American tropics, maybe 20 in tropical Asia; chiefly in the lowland wet forests of the Sundaic Region, less commonly in the wet mountain sides in north Mainland SE Asia. Many species, maybe most, are both widespread and abundant.



Examples of edible *Canarium* fruit and seeds; above, the flesh of *C. odontophyllum*, *dabai*, in a Sarawak market; boiled for edible flesh and seed; below, the commercial *pili* nut from the Philippines, here glazed in sugar.

Dacryodes



Dacryodes. 1-5, *D. costata*; 1, typical leaf form; 2, closer view of the double swollen leaflet stalk; 3, bark is gray, tight, with horizontal half-hoops; 4, the twig apex with small developing leaves, hairy or crusty granular; 5, typical sparse and open axillary inflorescence with tiny flowers; 6, *D. rostrata*, typical flower, 4 mm across, 3-part corolla with triangular petals; 7-8, when the diameters are large, the tree is typical of the family with low spreading thin buttresses and flaky gray bark, *D. rubiginosa*; 9-10, the mature fruit is variously colored red or yellow, globose or pointed, 9, *D. rostrata*, 10, *D. laxa*; 11, the dry fruit is characteristic of the genus in the thin exocarp that dries with deep wrinkles.

Dacryodes is vegetatively distinguished from *Canarium* by the lack of a stipule and the always entire leaflet margin. It generally overlaps in leaf form with *Santiria* and differs most decisively in the fruit: *Dacryodes* with a stigma central or only slightly eccentric, and with a flesh that dries strongly wrinkled; *Santiria* with an eccentric stigma and flesh that dries smooth.

Dacryodes rostrata is one of the most widespread species in tropical Asia, from Peninsular Thailand south to Singapore and Sumatra, through Borneo and northward along the wet east coast of the Philippines to NE Luzon. It is readily recognized by the stiff asymmetric leaf base, strong double swollen leaflet stalk, abundant white exudates from the leaf break, thin gray flaky bark. A few species are peculiar in one way or another, especially *D. laxa* with nearly sessile leaflets and a dense coat of long hairs.

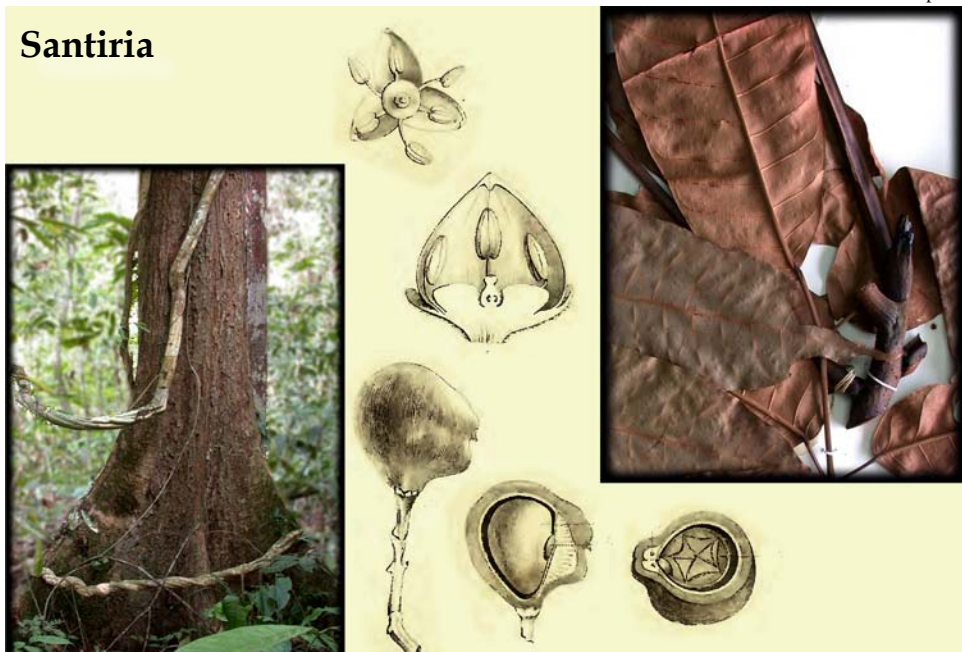
SANTIRIA. [Commemorates Blume's guide to Gunung Salak in Java]. Together with *Canarium* and *Dacryodes*, the genus *Santiria* is the third important genus of the family within the Sundaic Region, with some 18–23 species and a center of diversity in Borneo, eight in Malaya. It is vegetatively similar to some *Dacryodes* and those species of *Canarium* lacking both toothed margin and stipule. The leaf stalk is often stout, sometimes rounded above, but more often flat with sharp ridges or channeled. The resin is almost always clear and strong, not white. In general, the nerves tend to loop more often and more regularly than in *Dacryodes*. The stigma on the side of the fruit is a diagnostic feature of the genus.

Several species are widespread and abundant in the lowland Sunda Shelf forests. *Santiria laevigata* is a big tree with large glabrous leaves and conspicuous resin at the twig apex, especially in dry specimens. *Santiria apiculata* is one of the most consistent species of Burseraceae in the region, an abundant small tree that rarely reaches 20 cm DBH; readily recognized by the leaf with three to five shiny green leaflets, white twigs and a powerful turpentine odor. *Santiria griffithii* bears long leaves with many pairs of uniform leaflets.

HAPLOLOBUS. [Greek simple-lobe]. An uncertain number of species, perhaps as few as 10, basically a genus of New Guinea, but with extensions westward into Sulawesi. The genus, which is not well known, is generally similar to *Santiria* but differs in the apical rather than lateral stigma. It may well be nested within the large and variable *Santiria*. Until recently, the genus was known in Borneo solely from Beccari's type collection of *Haplobolus beccarii*, but the late Mr. Kochummen in his revision for the Tree Flora of Sabah and Sarawak added five additional species, four of which were based on single specimens, and three from the same location in Kapit District, Sarawak.

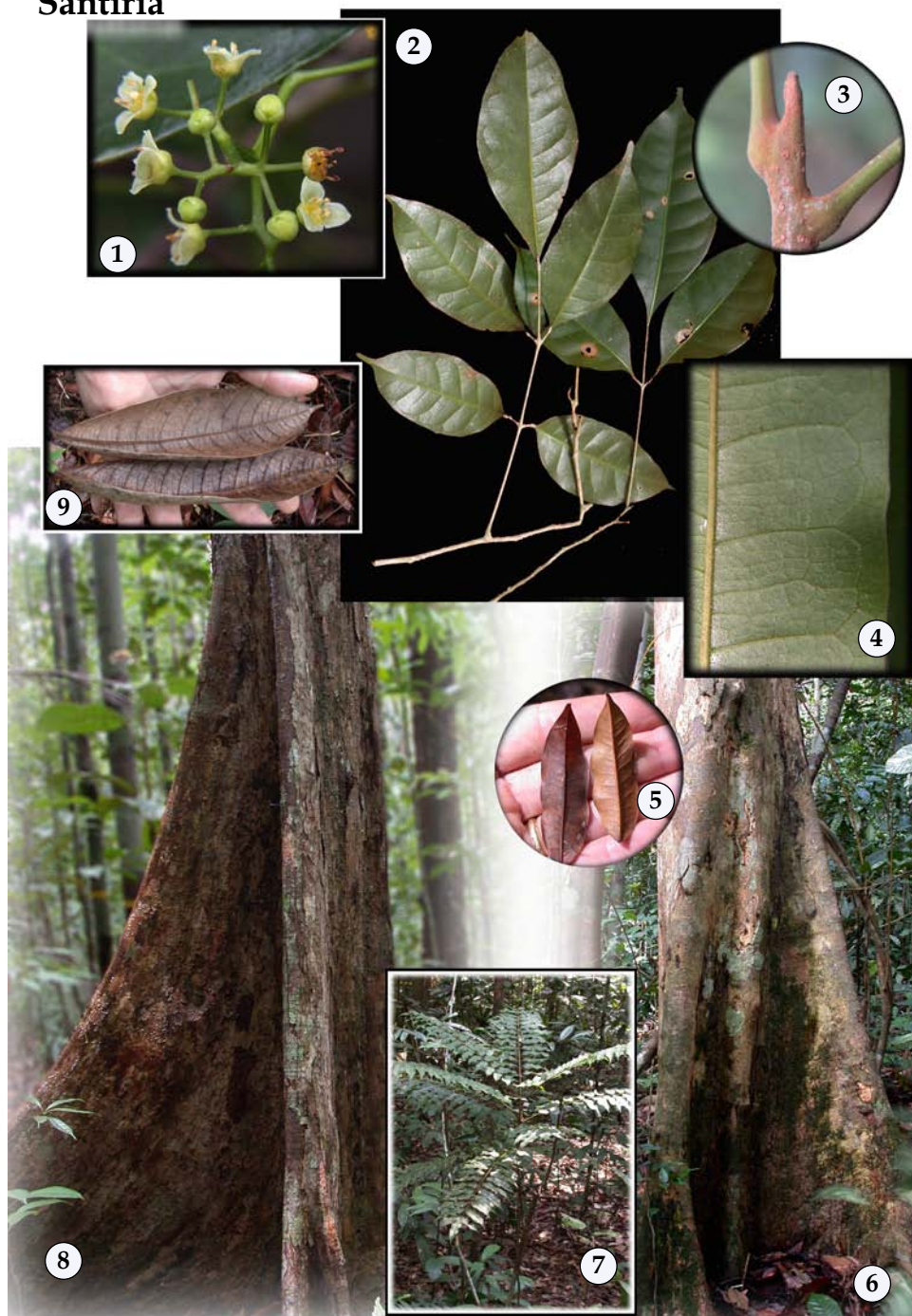
SCUTINANTHE. [Compound of Latin for a flat plate, Greek for flower.] One species, *Scutinanthe brunnea* of the Sundaic region, but also in Sri Lanka where it is said to be confined to the remnant lowland rainforests in the south-west. 30 m tall, 30 cm DBH, three-six pairs

Santiria



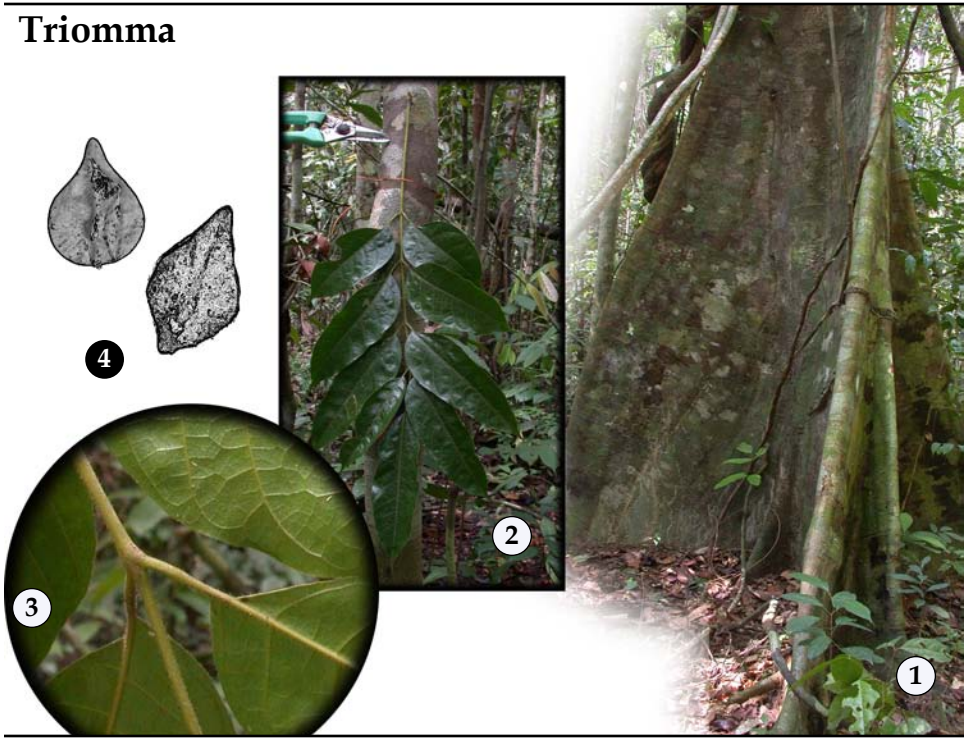
Santiria laevigata, a widespread and abundant lowland species, left, at Pasoh Forest, Malaya, 57 cm DBH, with scaly brown bark and short but wide and thin buttresses; the herbarium specimen on right shows the typical leaflet drying brown with wide spreading looped nerves and the twig apex covered in shiny dry resin; drawings of flower and the fruit with the lateral stigma characteristic of the genus. (Drawing adapted from BLUME *loc. cit.*)

Santiria



Santiria. 1, flowers of *S. apiculata*, tiny, 4 mm across, 3-part corolla; 2, *S. apiculata*, common and abundant small tree with glossy green foliage, five leaflets, smelling strongly of turpentine; 3, apex of twig, naked, but sometimes with granular crust; 4-7, *S. griffithii*, Pasoh Forest, Malaya; 4, leaflet blade nervation, with spreading looped nerves; 5, fallen leaflets of the mature tree shown in 6; 6, tall narrow buttresses, somewhat irregular trunk; 7, sapling leaf is especially long and narrow leaf with numerous leaflets; 8-9, *S. mollis* in Lambir Hills, Sarawak; 8, sweeping buttresses, shredding bark; 9, fallen leaflets, boat-shaped characteristic of the species.

Triomma



Triomma malaccensis, Pasoh, Malaya. 1, a 54 cm DBH tree, gray smooth bark and great steep thin buttresses; 2, the leaf with 7 or 9 leaflets; 3, the stalk unswollen, the base unequal; 4, the fruit a dry 3-sided capsule with thin winged seeds, unique among Asian Burseraceae.

of leaflets, leaflet stalks to 2.5 cm, swollen at both ends, base unequal, midrib sunken above, lateral veins eight to 10 pairs, raised below. The flowers bear parts in fives, the fruit is red hairy, densely pubescent with a greenish white inner face. Fruits ellipsoid, 4-6.5 x 2-3 cm, green, ripening yellow, with apersistent calyx. Usually at low densities, but consistently found in the lowland forests. Brown bark, often hooped, inner bark is bright red, sapwood pale. The leaflet stalks are not much swollen, the mid-rib sunken above, unusual in the family, the leaf is glabrous, dries stiffly papery, a bright red-brown below, and gray above.

TRIOMMA. [Greek, three-opening, in reference to the three-part dry capsule] Probably monotypic, *Triomma malaccensis*, endemic to the Sundaic Region, where it is a common emergent tree of the lowland forests on yellow sandy clay soils especially by streams (to 60 m height with high and narrow plank buttresses). The fresh wood yields a scant clear exudate that emits a strong mango smell. This is the only Asian Burseraceae with wind-dispersed seeds. The leaf is distinguished by the relatively unswollen leaflet stalks, strongly asymmetric leaflet base with nerves and veins drying red on the lower surface while the fresh leaves wither yellow. It might be confused with some of the compound leaf Anacardiaceae. Leaves of the sapling often bear a densely hairy rachis.

PROTIUM. [Greek for first or finest, thus the god Proteus, first son of Oceanus and Tethys, who could change his form, thus "protean", changeable or plastic; application to this genus is unclear; do not confuse with *Proteus* of the Proteaceae.] A genus of about 90 species, chiefly American tropics, represented in Asia by maybe five species, and these are restricted to the strongly seasonal parts of Mainland SE Asia, northward with two species in China, one endemic; also strongly seasonal parts of the Philippines, but not in the Sundaic Region.

The species in our region are all thought to be dioecious, but bisexual flowers are known elsewhere. The petals number five, valvate, the stamens once or twice the number of petals, the ovary four or five-celled, ovules two in each cell, drupe globose, ovoid or somewhat compressed, apex with the rudiment of style. The fruit is four or five lobed with a stony endocarp.

Protium serratum is an important tree found widely in Yunnan, India, and Mainland SE Asia, at 200-1000 m elevation; relatively fast-growing (one cm DBH per year) and reaching diameters that exceed one m. It is sometimes cultivated. It tends to be deciduous (always?), flowering together with the flush of new leaves in February, and producing small red fruit in July, often in enormous quantities. *Protium connarifolium* is a relatively small tree of Palawan and Sabah, while *P. javanicum* is found in seasonal Java and Bali.



Protium. 1–4, *P. serratum*, Cat Tien National Park, Vietnam; 1, stout, weakly buttressed trunk, dark scaly bark; 2, branches dense with fruit; 3, the fruit cut to show the hard endocarp and one (or more) seeds; 4, the toothed leaf margin; 5, *P. connarifolium*, Mt. Bloomfield, Palawan, Philippines, glossy green foliage, the leaf stalk double-swollen, the fruit 3- or 4-lobed; (Photograph 5, © Leonardo L. Co.)

#

ROSIDS (MALVIDS): SAPINDALES

ANACARDIACEAE

NAME: From the genus *Anacardium*, as below. In English as the cashew nut or mango family.

OVERVIEW: The Anacardiaceae are a pantropical family of 82 genera and about 700 species. Studies of molecular data show the family to be monophyletic, a core member of the Sapindales and sister to the Burseraceae¹. With that latter family there are many parallels and similarities: both are exemplified by large resinous trees with a dense crown, upturned rosettes of leaves that form at their extremities great pyramids of numerous small flowers. In particular, those Anacardiaceae with pinnately compound leaves, such as *Spondias*, bear a close vegetative similarity with some Burseraceae such as *Garuga*, so much so that only a familiarity with the individual genera will quickly distinguish them.

The morphological synapomorphies for the Anacardiaceae are microscopic and include flowers with an intra-

staminal nectiferous disc, ovules that are pendulous with a dorsal raphe and the micropyle up, and the unique chemical constituent 5-deoxyflavonoids. While decidedly monophyletic, the family is also highly heterogeneous in most features of outward form. This is especially so in the general form of the leaves, a situation that can confuse students at first: we find simple leaves in spiral clusters (*Mangifera* and *Gluta*), or alternating in a plane (*Drimycarpus* and some *Melanochyla*) or simple opposite leaves (*Bouea*) and rosettes of pinnately compound leaves (*Parishia*) and even twice compound leaves (*Spondias bipinnata*). The fruit is exceedingly plastic which has led to much taxonomic segregation without meaningful synthesis: about 27 of the 82 recognized genera are monotypic and the traditional alliances of genera as tribes have little molecular support.

A division of the family into two subfamilies, the Anacardioidae and the Spondioideae, has good molecular support. Furthermore, the subfamilies are significantly distinguished in ecological and geographic distribution as well. The *Anacardium* subfamily includes most of the species with simple leaves, and it is especially species-rich and abundant in equatorial Asia, perhaps represented in Borneo better than anywhere else in the world. While the group is also well-represented to the west, toward India, it is curiously poor or absent northward through

¹Pell, S. 2004. Molecular Systematics of the Cashew Family (Anacardiaceae). PhD. Dissertation. 207 pp. Louisiana State University. LA, USA.

Arrangement of Anacardiaceae

The following table provides an arrangement of those genera of Anacardiaceae that are represented among the trees of tropical Asia. A fully resolved cladogram is not yet possible, and many of the Asian genera have yet to be sampled, but the initial family-wide study by Pell (2005) reaches several important conclusions regarding the phylogeny of the family. Two main clades are strongly supported. The first is the subfamily Anacardioideae. These are trees, shrubs and some lianas, with leaves either simple or compound (by genus), stamens variable in number; carpels mostly one to three, one locule, one ovule, varied insertion, one to three styles, either fused or separate; one to three stigmas. Contact dermatitis is common among these genera. The second main clade is subfamily Spondioideae. These are trees or shrubs, leaves compound (rarely reduced to single leaflet); stamens two times the number of petals; carpels four to five, the ovary with four to five locules; one ovule per locule; ovules pendulous from an apical funicle; four to five styles; endocarp a mass of lignified and irregularly oriented sclerenchyma.

Several clades are supported within the Anacardioideae: *Mangifera* and *Bouea* are sister taxa; the most obvious difference is the opposite leaves of the latter. The bulk of the *rengas* trees, *Gluta*, *Melanochyla* and *Semecarpus*, although heterogeneous, form a clade. The *Rhus* complex is polyphyletic, horrid in taxonomy and nomenclature, and not of much relevance to tropical Asia. *Swintonia* and *Drimycarpus* appear to be sister taxa; in both genera, the main nerves enter directly to a marginal collecting vein. The genus *Camposperma* is singular, of curious ecology and geography, and uncertain in its phylogenetic placement. The genera *Parishia* and *Pentaspadon* appear to be sister taxa; they differ from most of the Anacardioideae in the compound leaves, and some species, such as *Parishia paucijuga*, have a copious white exudate that lacks allergenic reaction. *Buchanania* and *Androtium* appear to be sister taxa but of uncertain placement at present left unassigned to subfamily; the leaf blades are distinguished in that the panel formed by the main nerves is irrigated by a single dendritic vein.

The red lines indicate the presence of allergenic reaction.

GENUS		DIVERSITY, DISTRIBUTION & NOTES
Anacardioideae	<i>Mangifera</i>	58-70, tropical Asia, especially Malaya and Borneo, upturned clusters of leaves, flowers male and bisexual, 4-5 stamens, usually 1 fertile, 1 carpel, 1 ovule, fleshy fruit with fibrous flattened endocarp.
	<i>Bouea</i>	3, tropical Asia, like <i>Mangifera</i> but leaves opposite.
	<i>Gluta</i>	30, Madagascar, India to Borneo, flowers bisexual, parts in fives, superior ovary sometimes on long stalk, 1 carpel, 1 ovule, petals sometimes expanded as wings in fruit.
	<i>Melanochyla</i>	20,
	<i>Semecarpus</i>	75, small trees, leaves often with white margin or white lower surface, dioecious, single carpel with swollen 'apple'.
	<i>Holigarna</i>	8, India, east to Vietnam, big trees, spur-like bracts at leaf base, inferior ovary.
	<i>Drimycarpus</i>	2, 1 in N India to S China, 1 in Malaya & Borneo, leaves alternate in a plane.
	<i>Swintonia</i>	10, esp. Malaya & Borneo, winged fruit, leaves in upturned clusters.
	<i>Camposperma</i>	10, Asia (S. Thailand to Borneo), America, medium tree, gregarious in swampy gaps, monoecious, flower parts in fours,
	<i>Pistacia</i>	A messy, possibly deeply hybridized genus, the perianth of a single whorl; 1 cultivated species, and two native species, both rare.
	<i>Rhus</i>	Another messy deeply hybridized group of species, the sumacs,
	<i>Parishia</i>	6, Myanmar to Borneo, white exudate, winged fruit, big timber trees.
Spondioideae	<i>Pentaspadon</i>	5 (??), scant exudate, essentially 1 exceedingly widespread and abundant tree,
	<i>Buchanania</i>	25-40, India to Australia, a single vein irrigates panel between nerves, bisexual flower, 4 (6) free carpels, one develops as small kidney-shaped fruit with crisp bony endocarp.
	<i>Androtium</i>	1 (2), like <i>Buchanania</i> but with leaves alternate in a plane, Malaya, Borneo.
	<i>Dracontomelon</i>	2-5, S. Asia to Pacific, leaves and corolla like <i>Parishia</i> , trunk and fruit like <i>Spondias</i> .
	<i>Spondias</i>	10, Asia and America.
	<i>Koordersiodendron</i>	1, ecologically critical in East Borneo, north throughout Philippines, Sulawesi, New Guinea.
	<i>Choerospondias</i>	1, ecologically critical from central Thailand north to China, differs from <i>Spondias</i> in single united style.
	<i>Pleiogynium</i>	1-3, Java, Philippines, East tropical Asia to Australia, dioecious, leaflets with domatia in nerve axils, ovary 5-12 locular with same number of styles.
	<i>Lansea</i>	40, Africa with 1 east to Thailand, naturalized elsewhere.

the Philippines. In contrast, the *Spondias* subfamily comprises trees of the dry-seasonal lands, both to the west in Mainland SE Asia and to the east in the Philippines, with a scattered representation of *Dracontomelon* being the chief representative in the lowland equatorial forests. Most of the species in this group bear compound leaves, or rarely with a single leaflet, and are strongly deciduous.

In tropical Asia, Anacardiaceae comprise resinous trees with a black, brown or white exudate, or clear or white exudate that turns black. The leaves of trees in our region, while variable in form, are pinnately nerved and without stipules, although bud scales may cover the apex in a few species, and *Holigarna* and *Campnosperma auriculatum* bear small lateral spurs at the leaf base.

The leaf blade of many species is completely glabrous, with a stiff smooth varnished surface. In some *rengas* trees we find a velvety or harshly hairy indumentum. A few genera are characterized by domatia in the axils of the nerves on the lower surface of the leaflets. In *Swintonia* and *Drimycarpus*, the main nerves enter directly into a collecting nerve in the margin. A similar although much finer nerve is found in the leaflet of *Spondias*. While the dry leaves vary in color, they do not accumulate aluminium and so black and shades of bright yellow-green are rare.

Extra-floral nectaries or ant associations are not known among the species covered in this volume; however, more than a few species of *Semecarpus* in New Guinea are said to have ant-inhabited twigs.

Almost all species of Anacardiaceae bear a big pyramidal inflorescence of tiny flowers. The floral parts are essentially in fives, with several genera in fours by reduction. The flowering habit tends to be massive - millions of flowers can color the entire canopy. I do not think any of our trees are cauliflorous.

Trees of the Anacardiaceae can persist in the forest shade without growth at all for long periods, but once sunlight is reached, or if a tree fall brings light to the forest floor, growth can be exceedingly rapid, often more than one cm DBH per year. The population dynamics are likewise very active with great crops of seeds and fruit, numerous recruits and much death among the saplings. The spatial structure of populations varies between those species with winged diaspores, such as *Parishia*, *Swintonia* and some *Gluta*, which tend to have saplings clustered about the mother tree as in a Dipterocarpaceae, and the more fleshy fruited species such as mangoes which have a wide dispersion of saplings.

A few notes on pollination are given under the individual genera. With regard to dispersal, the 'apple' of *Semecarpus* species is edible in the fashion of the cashew apple, and is dispersed by animals. *Buchanania* has small fruit that are eaten whole, the seeds likely gut passed or regurgitated. The fruit of the mangoes are large-seeded and the fruit dispersed by primates.

MANGIFERA. [Latin, mango bearing.] The genus includes between 58 and 70 species. The Malay name is *mangga*, or some variant; the cultivated species often have local names. Mango species are uniform, evincing low levels of molecular divergence in the scant sampling to date.



Mangifera caloneura, Huai Kha Khaeng, Thailand, the form of the tree, tall and straight with a dense globe-like to pyramidal crown is typical of much of the family, the individual leaves typical of the genus.

The center of species richness lies in the Malay Peninsula with slightly less richness in Sumatra and Borneo. The relative poverty of the genus in the Philippines is notable. A total of five species are recorded, however two are rare, two other Sundaic species, *M. caesia* and *M. longipes*, and are found no further north than Mindanao and Palawan, and only the endemic *M. altissima* is widespread and abundant from Mindanao to northern Luzon. The situation is paralleled in *Bouea* which is also absent from the Philippines.

While the mangoes are all roughly similar in general vegetative and floral form, it is certainly possible to distinguish most species by vegetative characters, although gaining experience is difficult in that most species grow at exceedingly low densities. The individual species vary in the shape of the leaf, and also in the bark characters, which are poorly explored. The mid-rib is always raised above, leaf blade is always glabrous and usually shiny, elliptic to narrow oblanceolate. The leaf stalk is swollen below, sometimes greatly, and tapered above; it may be 15 cm long, or nearly absent. The exudate is clear or brown or thin white in the trunk of a few species.

The flowers vary in number of parts - either four or five - and in color, the form of the disc, in fruit shape, and the details of mesocarp texture. Most flowers are 5-10 mm across, parts in fives, the petals reflexed. The inflorescence includes vast numbers of male flowers and generally fewer bisexual flowers. In most mangoes, the pistil sits within a thick nectar-producing disc, but in a few species the disc is no wider than the pistil or absent



Mangifera. 1-7 & 10, *M. indica*, cultivated, Philippines; 1, characteristic habit of dense dark green foliage in upturned spiral clusters with terminal infructescence, pendent from the weight of the fruit; 2, terminal bud protected by scale leaves; 3, typical leaf shape; 4, the leaf stalk is thicker near the stem, without stipules; 5, characteristic venation; 6, terminal open many-flowered pyramidal inflorescence; 7, fully ripened fruit of export quality; 8, *M. panjang*, the horse-mango, thick skinned and fibrous flesh, Miri Market, Sarawak; 9, line drawing and X-section of mango flower; 10, photograph of mango flower showing single fertile stamen and thick nectaries on the petals. (Drawings adapted from BALLION *loc. cit.*)



Mangifera, leaf and bark diversity among the native mangoes; 1, *M. griffithii*, ordinary leaf, pale warty bark with whitish exudate; 2, *M. gracilipes*, thin tight pale bark, small short-stalked leaf; 3, *M. superba*, long-stalked, large narrow leaf, thick blackish twigs, scaly bark; 4, *M. foetida*, stiff elliptic leaf, spreading nerves, short-scaly and rough bark; 5, *M. aff. lagenifera*, Bukit Timah, Singapore, large tree with scaly bark, the inset of mature leaf and the, the latter with very long strap-like leaves; sapling; 6, *M. macrocarpa*.

altogether. While that difference is considered a basis for a sectional split in the genus, there is no molecular evidence to support it.

Mangifera is distinguished from the *rengas* genera by exudate color. Some *rengas* have a sunken mid-rib above while in mangoes it is always raised. The general leaf shape and clustered rosettes of some *Barringtonia* are superficially like a mango, but mangoes differ in the exudate and odor, the entire leaf margin, and the solid twigs. Often one finds fallen fruit that are ostensibly like a mango, a drupe 3-10 cm across with a pungent characteristic odor, sometimes the flesh is gummy with white exudate, but these may well be fruit from some of the Burseraceae such as *Canarium* (Burseraceae) or the unrelated *Irvingia* (Irvingiaceae).

Mangoes are a characteristic part of the lowland rain forest, almost every forest will have more than a few species. However, these beautiful trees are encountered so infrequently and they flower so rarely that it is difficult to gain much field experience. Big jungle mangoes may flower no more often than once in seven to 10 years.

When they do bloom, they can yield an enormous crop that is appreciated and dispersed by large and small animals alike.

Mangifera indica is the cultivated mango. Its origin probably lies in eastern India or Myanmar, and it is often treated as synonymous with wild trees that fall under the names *M. indica*, *M. laurina* and *M. sylvatica*. The mango is now grown all over the world in more than 1000 named varieties, with an uncertain total production because most of the fruit is consumed locally.

Considering the economic importance of mango, it is astonishing how little is known about its pollination. A large tree may bear anywhere from one to 10 million flowers and about 80 % or more may be exclusively staminate. Although reports of fruit set without pollination are known, cross-pollination is generally thought to be required and is typically effected by flies and bees. Eco-

²Kostermans A. *et al.* 1993. The Mangoes: Their Botany, Nomenclature, Horticulture and Utilization. Academic Press.

³Litz, R. (ed.) 2009. The Mango: Botany, Production and Uses. 2nd edition. Cabi. U.K



Bouea. 1, *B. macrophylla*, Pasoh Forest, Malaya, cultivated tree with dense foliage; 2-5, *B. oppositifolia*; 2, opposite leaves, pointed apical bud; 3, forest tree, fruit with seed, purple flesh within; 4, characteristic bark; 5, cultivated fruit in Bangkok market.

logically, we must wonder why the mango flower bears only a single fertile stamen and then produces such an over-abundance of male flowers.

Mangifera foetida, the horse mango, is one of the more abundant and widespread of the wild forest mangoes. It appears to be one of the parents of cultivated 'hybrid species' such as *M. odorata* (*kuwini*, hybrid origin confirmed by molecular data) and the still putative hybrid, *M. pajang* of Borneo.

The fruit of many mango species is eaten when the fruit is still green and astringent. The flesh is cut very thin and pickled, or shredded for a salad. Newly emergent mango leaves are a popular salad, while the dry leaves are a favorite for smoking fish. There is no regional expert at present and unlike the dipterocarps, very few wild mangoes of the wet equatorial forest have been cultivated in Botanic Gardens. While natural fruit and seed are not easy to obtain, it is easy enough to find saplings near the large mother trees. We might suggest that their cultivation in Botanic Gardens and Research Centers should be a priority.

BOUEA. [Commemorates Ami Boue, botanist, geologist, born Hamburg Germany, co-founder of Geological Society of France, etc., d. 1881.] Ten basionyms represents perhaps five species. The Malay is *kundang* or *rumenia* or some combination or variation, sometimes the Spanish *gandaria*. These are found in the forest and in cultivation from Mainland SE Asia to the Sundaic Region, to Java and Sulawesi. *Bouea* is an obvious genus in that the leaf blade is clearly that of the mango type, and yet the arrangement is strictly opposite. The several species form a small monophyletic genus allied to *Man-*

gifera, an arrangement confirmed by molecular data. The flower is five-parted and the stamens are all equal and fertile, the nectariferous disc is reduced.

Of the common species, *B. oppositifolia* bears narrow thin leaves with narrow pointed buds whereas *B. macrophylla* bears broad thick leaves and a thick broad bud. The identity of the trees of Mainland SE Asia, both wild and cultivated, which includes *B. burmanica* and *B. poilanei*, needs further study with regard to its relationship with *B. oppositifolia*. Also, we find distinctive wild forms in Borneo that are unnamed.

The leaves could be mistaken for *Kayea* (Calophyllaceae) which bears stiff shiny opposite leaves with nerves that are similarly arched, and some *Kayea* have a terminal bud that is pointed and covered with sharp scale leaves. However, most *Kayea* species should have a little yellow exudate, whereas if *Bouea* has any exudate it is clear and resinous; also, the fine venation of *Kayea* is distinctively boxed.

The fruit of *kundang* is like a small elliptic mango, with sour flesh, and a seed that includes remarkable violet-colored cotyledons. The tree bears a compact conical crown with dense foliage that casts a very deep shade below. Formerly, these were widely planted in Malayan kampongs. Today, they are perhaps more extensively grown in Thailand where they bear fruit that is generally superior to that of the Malayan representatives.

ANACARDIUM. [Greek for heart-like, a poor description of the nut.] This genus, native to the American tropics, includes about 10 species, but only one is widely cultivated, the cashew of commerce, *Anacardium occidentale*. It is commonly found in villages and small



The cashew, *Anacardium occidentale*, is originally from Brazil, but is now widely cultivated in dry-seasonal parts of tropical Asia, here in Palawan, Philippines.

plantations in many of the strongly dry-seasonal parts of tropical Asia. The highest volume may be found in India, where the apple is also an important fruit, however, the highest quality nuts come from Vietnam and from Palawan Island, Philippines.

GLUTA. [Evidently derived from Latin *glutin*, glue, in reference to the resin.] 30 species, (including *Melanorrhoea*). The Malay *rengas* is widely used for this and other genera with black exudate and strong allergic reaction. From Madagascar and India to Mainland SE Asia and also eastern tropical Asia. While about half the species are found in Borneo, not a single species has been credited northward into the Philippines.

These trees often bear black resin on the trunk and twigs and even in patches on the leaves which can help distinguish them from mangoes and from some Sapotaceae (which should also bear stipules). The leaf stalk is variable in being short or even absent or relatively long. The flowers are bisexual, the parts in fives, the stamens (sometimes 10 or more) are all fertile. The ovary is borne without a disc and sometimes on an extended stalk above the calyx. It includes a single locule and one stigma, matures as a dry drupe-like fruit in some species with expanded petals as ineffective wings. *Gluta walliichiana*, can become very numerous in older secondary forest.

MELANOCHYLA. [Greek, black-sap.] 30 species, Mainland SE Asia and especially the Sundaic Region with 20 species in Borneo (eight newly named!) and yet,

as in *Gluta*, not one species is claimed for the Philippines.

The leaves are in upturned clusters or alternate along horizontal branches, the midrib often strongly raised, the blade very often with stiff red or yellow hairs (which distinguishes it from the mango). The trunk often with stilt roots. The corolla forms a shallow cup around the ovary and leads to the impression that the flower is inferior, but it is not; the fruit is usually a drupe, and is often red hairy.

SEMECARPUS. [Greek, sign and fruit, in reference to the reputed use of some fruit juice as ink.] About 75 species. The richness of this genus in places such as Borneo was greatly underestimated and a new review may boost that number by half. Mainland SE Asia claims an additional dozen or more species. Most species are dioecious, but there has been little field work on reproduction. The fruit is subtended by a swollen stalk much like the 'rose-apple' of the cashew fruit and more than a few are possibly edible. The apple is of course a means to attract dispersers which one might presume to be strong flying birds. The leaf blades generally has a midrib that is sunken above and a stark whitish undersurface and a white edging to the leaf blade. The exudate from the twig or leaf break is often clear or even white at first, but quickly darken to jet black. Getting to a meaningful species name is not easy. The genus very much needs a fresh review.

HOLIGARNA. [Reputedly from a vernacular name.] Eight species of medium sized trees of the Indian subcontinent distinguished by the inferior ovary and bract-like spurs on the leaf stalk. Two species extending eastward, especially *Holigarna kurzii*, all across Mainland SE Asia, and *H. albicans* to lower Myanmar.

SWINTONIA. [Commemorates G. Swinton, government official in Bengal, India, ca. 1840.] Maybe 10 species, centered around the Malay Peninsula with species often geographically restricted. Four are noted in Mainland SE Asia of which only one, *Swintonia schwenkii*, is found south into the Malay Peninsula where it is joined by three others. The Malay name *pitoh* is widespread, but also as *merpauh*, or *perpauh* in Malaya and *selan* in Sarawak.

The species are all rather similar to one another and readily recognized to genus: big trees with leaves in tight upturned clusters, the nerves enter the leaf margin, the blade white below. These trees can become exceedingly abundant along ridges, regenerating large numbers of saplings, and can even become the most common species within small areas. They range from coastal ridges up to 1000 m or more elevation. The fruit are essentially wind dispersed with the aid of wings that develop from the petals, not the calyx lobes.

DRIMYCARPUS. [Greek, acid-fruit.] Two species geographically far removed from one another. The two

species share a peculiar flower in which the ovary with a single blunt style is embedded in a calyx tube, the perianth falling away but persisting at the crown of the 0.5-1 cm fruit. The trees are monoecious with mixed bisexual and staminate flowers.

The genus was founded on *D. racemosa*, a not uncommon species of the seasonal forests in north India, Nepal, across northern Thailand and Vietnam to S China.

Drimycarpus lurida, is surprisingly well-known as *ren-gas-api* in Malay. This is a medium-sized tree, widespread in the lowland rainforests of the Sundaic Region, but at low densities, perhaps falsely described as rare based on the few fertile collections. This odd species was first described from Malacca and struggled through unhappy marriages with *Semecarpus* and *Swintonia* until forming its current alliance. It is distinguished by the stout, uniform, but sinuous stalk and nerves that enter the leaf margin as in *Swintonia*. However, in *Swintonia* the lower

Gluta



Gluta. 1, Line drawings and diagrams of *G. reinghas* flower; photographs 2-9 from Lambir, Sarawak; 2-3, a species allied with *G. wallichiana*, tall, straight with *meranti*-like red-brown deep furrowed bark; 4, 8-9, an unnamed species of *Gluta*, close to *G. malayana* but with shortly stalked leaves, young fruit with short calyx wings; 5-7, *G. laxiflora*, the fruit without wings, the bole flared and shortly buttressed, the leaf is spear-shaped, the long stalk is swollen at base, the leaves in loose clusters, it can be confused with Sapotaceae but the exudate is black. (Drawing adapted from BALLION *loc. cit.*)

ANACARD DERMATITIS

A few words about Anacard poisoning are appropriate. Many species in the family produce a class of chemicals called urishols that initiate the skin rash for which some species are notorious. The "Poison Ivies" of America, species of *Rhus*, are the best investigated and their main constituent is alkylated o-dihydroxyphenol.^{1,2} Although the *rengas* trees of Asia are at least as virulent, the details of their constituents are apparently unstudied, this despite the serious problems posed by *rengas* for tourism and recreational use of forests. The allergenic effects come from contact with species in the *Anacardium* subfamily, and only in some genera with much variation among species. *Gluta*, *Melanochyla* and *Semecarpus* are the most feared, but some people are also sensitive to mango, especially the resin from fresh twigs.

Clinically, the rash is an allergic reaction of the skin brought on in 6-48 hours after contact. While it appears that humans are not initially allergic to Anacards, repeated contact with the plants creates a persistent sensitivity. If that is true, then the sensitivity is very general among species of Anacardiaceae, because first time visitors to tropical Asia are routinely affected by the local *rengas*; perhaps after being earlier sensitized by contact with *Rhus*.

The key to understanding *rengas* dermatitis is to note that it is an allergy, not a simple burning as from an acid or alkali. Once symptoms develop, it can be neither washed off nor neutralized. The chemicals do not cause the blistering, itching, reddening and other effects, rather it is the body's own reaction, and while this is usually localized to the point of contact, in some people the allergic reaction spreads to other spots. As with most allergies, there is a great deal of variation among individuals and much mystery.



Rengas wood sample, Sarawak Timber Council, probably a species of *Gluta*, characteristic of the family in the hard tight red grain and black resinous streaks.

The only currently accepted remedy is the application or injection of cortisone or histamines. Tubes of 1% cortisone cream are available without prescription in most countries. Traditional remedies for Anacard dermatitis are many and of generally untested efficacy. Many rely on the application of a base or alkali. Others suggest the application of products rich in tannin such as strong cold tea. Others recommend cleaning regularly with alcohol. A common remedy in Sarawak is a small amount of oil heating to smoking with a large amount of salt then applying the oil when cool. Some claim that the juice from *putat-air* (*Barringtonia racemosa*) is effective. While these remedies may offer relief from the symptoms, they offer little impact on the allergy itself. At present, there is no available prevention other than avoiding contact.

¹Gross, M. *et al.* 1975. *Phytochemistry*. 14: 2263-2266.

²Aguilar-Ortigoza, C. *et al.* 2003. *Economic Botany*. 57: 354-364.

Melanochyla



Melanochyla. 1-3, *M. auriculata*, Pasoh, Malaya, small stilt-rooted tree, the ground covered with hard resinous leaves, saplings with a single stem and dense cluster of leaves with overlapping base; 4-5, *M. tomentosa*, Pasoh, Malaya, leaves alternate in a plane, flower and fruit, sparse terminal inflorescence.

Semecarpus



Semecarpus. 1 & 4, *S. longifolius*, Philippines, maturing fruit with variously colored 'apples', pachycaul tree with rosette of long nearly sessile leaves; 2, *S. densiflorus*, Philippines, hard dry fruit, note glaucous lower leaf surface typical of many *Semecarpus*; 3, the flower of a yet unidentified species of *Semecarpus* from Bataan, Philippines; 5, *S. curtisii*, Malaya, leaf with white margin, characteristic of many *Semecarpus* both fresh and dry. (Photographs 1, 2, & 4 © Leonardo L. Co; 3, © Ulysses Ferreras.)

Holigarna

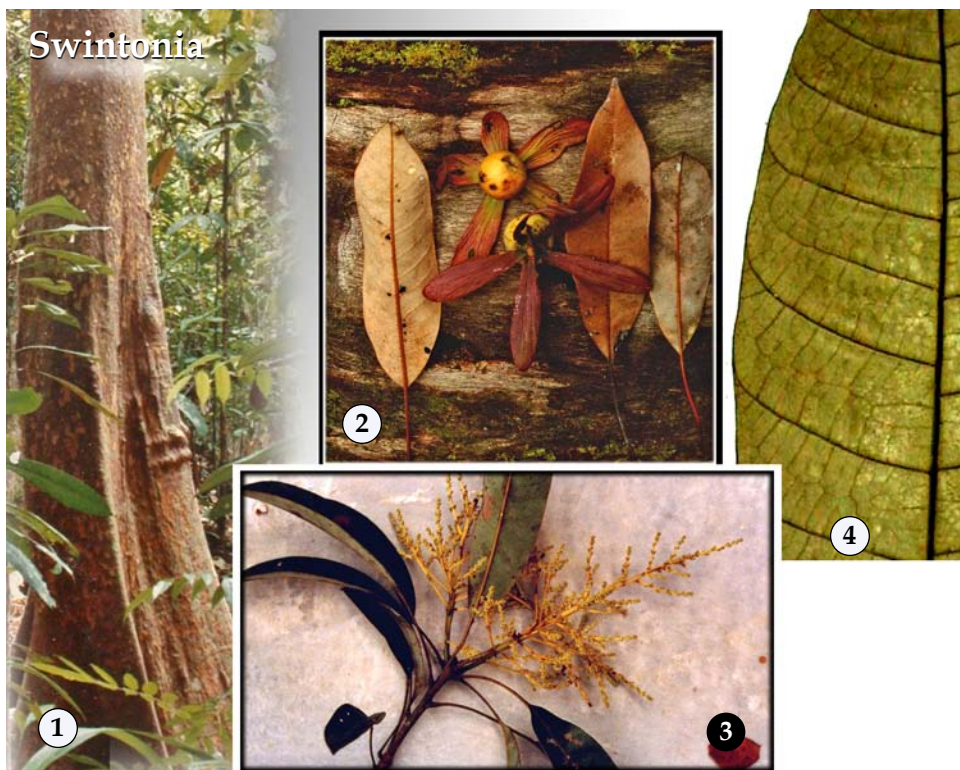


Holigarna longifolia. Note the fine stipules-like scales on the lower leaf stalk. Adapted from Plate 282 in ROXBURGH *loc. cit.*

leaf surface is white and the leaves are arranged in up-turned spiral clusters, whereas in *Drimycarpus* the leaves are green and displayed alternately on horizontal branches. Mr. Kochummen named as *D. maximus* a population with robust leaves and fruit from 7th Division, Sarawak, in Borneo.

CAMPNOSPERMA. [Greek, bent-seed.] About 10 species, curiously scattered pantropically, with two in the Neotropics, and one newly discovered in Madagascar, otherwise maybe six species from Sri Lanka and India east to New Guinea, but evidently not north into the Philippines. The American trees look and behave astonishingly like the Asian trees and there is no reason to think the genus is not strongly monophyletic. Where it fits among the Anacardiaceae is a more difficult question.

These trees are well known by the Malay name *terentang* or some variant. These are medium sized trees to 35 m height, the flowers unisexual (monoecious) diagnostically with parts in fours, stamens twice the petal number, the ovary with a short style, the fruit a single-seeded drupe. Species of *Campnosperma* grow rapidly in full sun and typically in swampy places although they often show up in cleared land sometimes forming a short-lived



Swintonia. 1-4, Lambir Hills, Sarawak. 1, *S. floribunda*, large tree with steep shallow buttresses; 2-4, *S. schwenkii*; 2., fallen leaves and fruit with winged calyx; 3, inflorescence, terminal, many small flowers, pyramidal; 4, the venation is typical of Anacardiaceae, but the nerves enter directly into the leaf margin.



Drimycarpus luridus, Lambir, Sarawak, the leaves alternate in a plane, the stalk long and of uniform width, the nerves thin and entering into the leaf margin, as in *Swintonia*.

monospecific stand that creates a deep shade above and a thick bed of resinous leaves below. On dry ground, they gain a patchy dominance only in gaps. Maximum growth rates easily exceed one cm DBH per year.

Camposperma auriculatum bears a pair of very distinctive ear-like lobes at the base of the leaf stalk, the leaf blade to 20 cm broad. It is reported that *C. brevipetiolatum* is exceedingly abundant in swamps of New Guinea and also finds its way over the oceans to form a significant vegetation in some Pacific Islands. How odd, then, that *Camposperma* has yet to be documented for Mindanao and Palawan.

PISTACIA. [Greek, in reference to the reputed healing properties of the resin.] A genus of nine species with an odd scattered distribution from the Mediterranean to Asia, and from Texas to Central America. The genus is unique in the family in the perianth of a single whorl. One cultivated species, *Pistacia vera*, the pistachio nut of commerce, and two species native to Mainland SE Asia, both rare. (Not illustrated.)

RHUS. [From the classic name of the European sumac.] A difficult genus of at least 200 species, chiefly of the northern latitudes, including the species of poison ivy of North America. In tropical Asia, these are gener-



Camposperma auriculatum, Pasoh, Malaya, ground littered with resinous, rot-resistant leaves, the trunk columnar, gray thin-barked, the fallen leaf long-stalked.

ally uncommon small trees, represented by five species, another four in New Guinea. *Rhus chinensis* (illustrated) and *R. succedanea* are abundant in mountains of Mainland SE Asia at around 1000 m elevation, but not reaching the Malay Peninsula. *Rhus nodosa* extends from the central Malay Peninsula east to Borneo and beyond. *Rhus borneensis* is endemic to Borneo, and is extremely odd in that it is claimed to be truly simple-leaved, not just a compound leaf reduced to one leaflet. This should be examined in fresh material. *Rhus taitensis* from the Pacific Islands as far west as east Java and Sulawesi. The last species can reach sea-level, but the others are confined to mountains above 1000 m, usually in gaps of wet mossy forests.

PARISHIA. [Commemorates C. Parish, d. 1897, British missionary and botanist of Myanmar.] About six species, Myanmar to Borneo, and the Philippines. All the species of *Parishia* co-occur in Borneo, except *P. malabog*. They can often be found in forests relatively close together. Comparative studies would be useful. These trees are well known by the Malay names *layang-layang*, *sepul* and *rengas-susu*, and *lelayang* for the timber, while the Iban *upi* is widely used in Borneo.

At present, *Parishia* is allied with the *Anacardium* group because of the single carpel; however these tree display numerous differences with the mangoes that suggest a complex relationship: pinnately compound leaves, white exudate (sometimes copious), absence of contact dermatitis, and calyx lobes expanded as wings. This is the only Anacardiaceae to have the calyx develop as wings -



Rhus chinensis, about 1800 m elevation, Central Highlands of Vietnam.

in other genera the wings are from the petals. Be careful not to confuse the winged fruit with a dipterocarp.

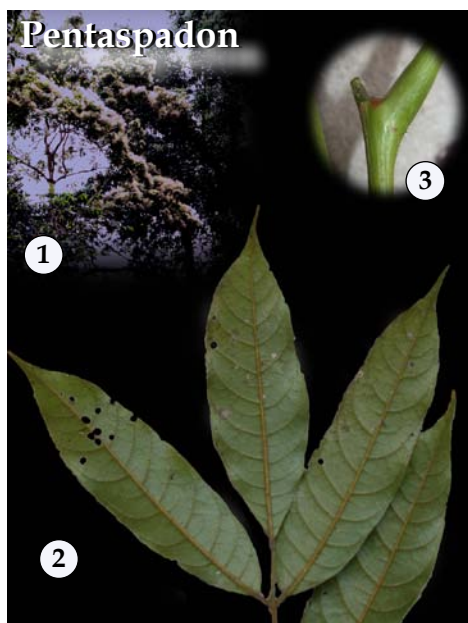
These are sometimes exceedingly big trees, the bole with steep plank buttresses, or in swampy ground with stilt roots. The bark is dark brown, gray or reddish, scaly or shallow fissured; flowers unisexual (dioecious) parts in fours, the ovary one-locular, the style three or four lobed.

Parishia species are common and widespread elements of the lowland forests of the Sunda Shelf. The saplings often show up in great abundance surrounding the huge mother-trees, especially *P. motleyi* where great numbers of saplings often occur, all completely uniform. The dry leaves of *P. insignis* are indistinguishable from *Dracontomelon dao*, but look for evidence of scant white exudate and more extensive insect damage which is common in the former.

PENTASPADON. [Greek, five-eunuchs, in reference to the five sterile stamens.] Maybe five species, two in Vietnam and Laos; others from Thailand to the Solomon Islands. All generally known under the same names *p'lajau* in Sarawak, *pelong* in Malaya. (In some books they still appear under the genus name *Microstemon*).



Parishia. 1, *P. paucijuga*, Pasoh Forest Malaya, 50 cm diameter above the steep plank buttresses; 2, *P. insignis*, Bukit Timah, Singapore; one of the last large trees in Bukit Timah, now protected by lightning rods; 3, *P. maingayi*, Lambir Hills, Sarawak, with great open terminal and pyramidal inflorescence; 4, *P. sericea*, Lambir Hills, 7 mm long urceolate flower; 5, *P. insignis* fruit (about 8 cm long) with 5 free calyx wings (one hidden); 6-7, dry leaves *P. maingayi* (left) and *P. insignis* (right), pinnately compound.



Pentaspadon motleyi, Pasoh, Malaya; 1, dense terminal pyramidal inflorescence of many small white flowers; 2, terminal portion of compound leaf, terminal leaflet, lateral leaflets slightly asymmetric; 3, terminal bud of twig.

Some forms are hairy, some glabrous, but never with white sap at the leaf break although scant droplets can be seen at the cut bark. The leaf stalk is usually red or violet when fresh.

These trees are sometimes abundant, especially along streams and river ways, and are especially conspicuous when in bloom, their spreading canopies are dense with tiny white flowers. The inflorescence axes are long persistent on the ground beneath the big trees. An oil is taken from the trunk, as in the manner of tapping *keruing*, and used as a skin medicine.

ANDROTIIUM. [Greek, male-eared, reference to the diagnostic lobes on the stamens.] A genus comprising one poorly collected species, *Androtium astylum*, found at low density in lowland forests in Malaya and Borneo. The leaf stalk is thick all along its length, pinched a bit where it joins the blade, the panels between nerves with a single dendritic nerve, looking much like *Buchanania sessifolia*, but the leaves are alternate on horizontal twigs rather than in upright clusters. The leaf blade dries papery brown with a shiny metallic lower surface. The species is distinguished from *Buchanania* by the stamens which are twice the number of petals, the anthers basifixed, the connective prolonged and two lobed.

This is a small tree of uncertain ecological requirements. It has small bisexual flowers similar to *Buchanania* borne in axillary paniculate inflorescences that yield small bean-shaped one-seeded berries.



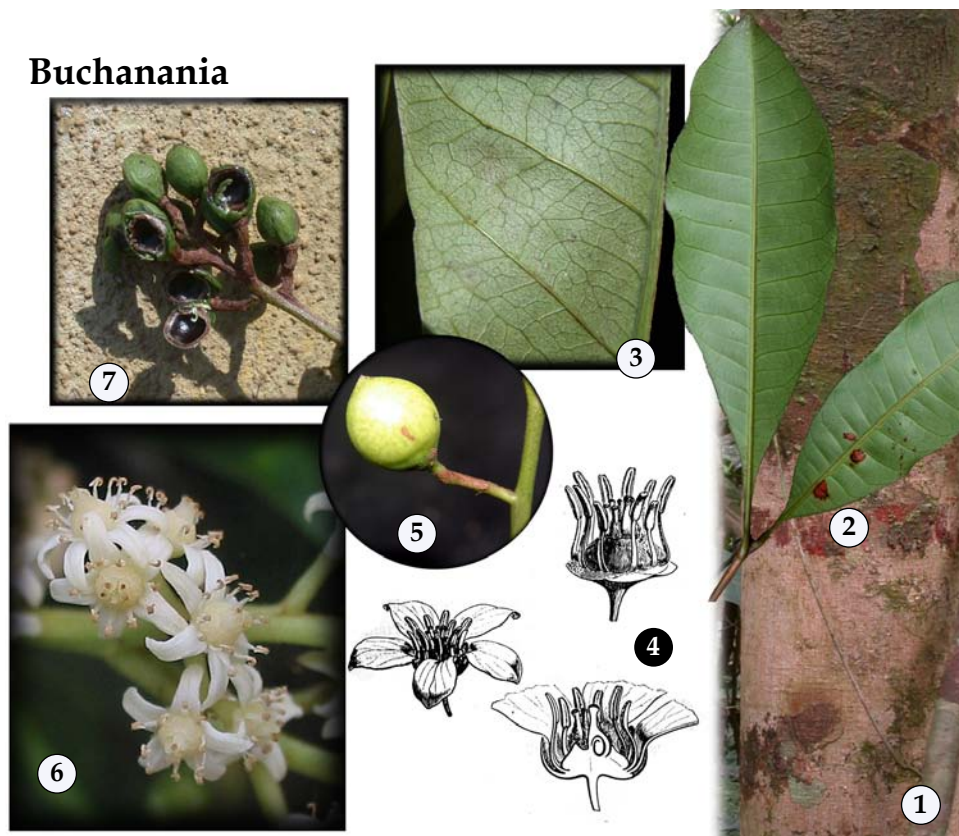
Androtium astylosum, Lambir Hills, Sarawak, leaves are borne alternately in a plane, the venation as in *Buchanania*.

BUCHANANIA. [Commemorates F. Buchanan-Hamilton, Scottish naturalist, d. 1829, who succeeded Roxburgh at Calcutta and who first described one of



Buchanania reticulata, here as a 4 m tall shrub in strongly dry-seasonal coastal Vietnam near Cam Ranh Bay; note the fruit, axillary floral spikes, and the fine reticulate nervation.

Buchanania



Buchanania. 1-3, 5, *B. sessifolia*, Pasoh Forest, Malaya; 1, rough but unbroekn pinkish bark, 10 cm DBH; 2, leaf, shortly stalked, in loose clusters; 3, typical venation with a single vein irrigating the panel; 4, line drawing and diagram of flowers (from BALLION *loc. cit.*); 5, young fruit; 6-7, *B. arborescens*, Philippines; 6, flower; 7, fruit, with thin green exocarp, hard endocarp, shiny black within, typically empty.

these trees from Myanmar in 1798, but did not name it.] Maybe 25-40 species, India to Australia, about eight in Mainland SE Asia, only four species within the Sundaic Region. The flowers are bisexual and bear four-six free carpels of which only a single one develops as a small asymmetric drupe. It forms a clade with *Androtium*; on morphology, they have always been associated with simple-leaved Anacardiaceae, but the molecular data suggests an uncertain affinity with the *Spondias*-group.

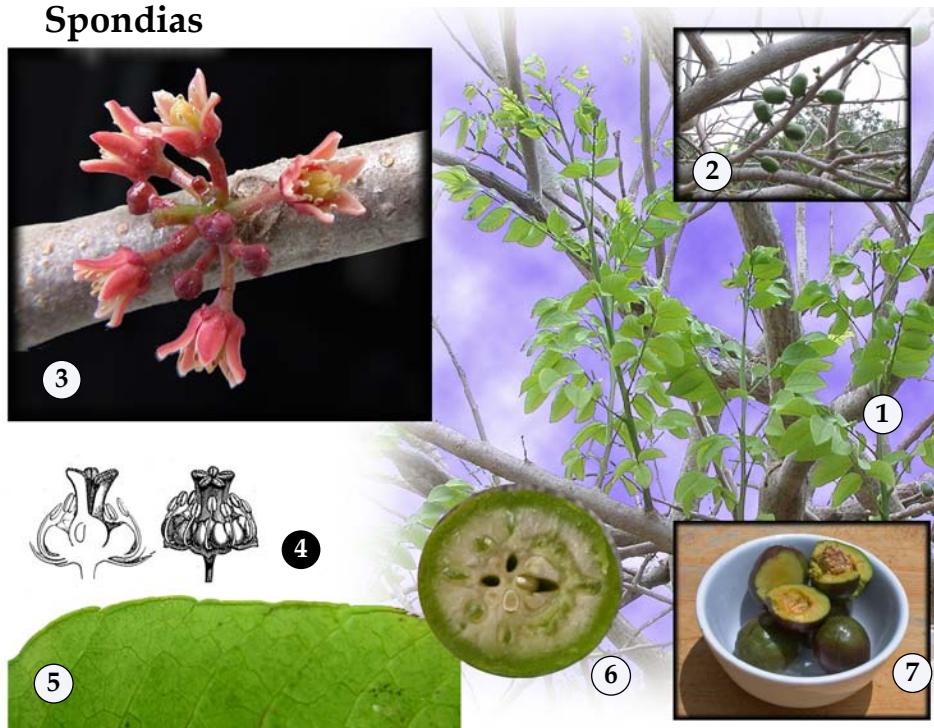
Buchanania sessifolia is known in Malay as *otak udang* presumably for the river-like vein that irrigates the panel between the main nerves, somewhat resembling the nerve of a shrimp. This is a common and abundant tree everywhere in the lowland forest and seems to exhibit a uniform ecology everywhere. Typically found in forest gaps and margins, it grows quickly to about 10-12 cm DBH and then dies soon thereafter. It blooms commonly, the inflorescence yields numerous small drupes that are greedily taken by a variety of understory birds even while still unripe.

Buchanania arborescens is found widely from N Thailand to Borneo then north to the top of Luzon. It is most

abundant in open forests of the dry-seasonal lands. In the mature lowland equatorial forest it is chiefly in gaps and especially on river banks. It seems to be completely uniform throughout the range and stands out when in flower because the entire canopy is filled with creamy white flowers.

SPONDIAS. [Greek classical name for the plum, which the fruit somewhat resembles.] Usually described as a genus of 10 Asian and seven Neotropical species, but species limits are unclear. The natural taxonomic complexity is exacerbated by centuries of cultivation and transport. All species have a bony endocarp with one or more seeds; the leaflet most always has a collecting vein within the margin. Kostermans emphasized the structure of the bony endocarp and decided to treat *Spondias* as five genera⁴. He resurrected three old generic names and created one new genus, *Haplospondias*. *Spondias lakonensis*, cultivated and wild, is found in China and Mainland SE Asia; two species, are segregated as *Allospondias* while *Spondias philippinensis* is treated under *Solenocarpus*. The

Spondias



Spondias purpurea, cultivated, Philippines; 1-2, deciduous tree with pinnately compound leaves that flowers and even when leafless; 3, flower, five spreading red petals; 4, Line drawing and diagram of flower; 5, the leaflet nerves enter the margin, the margin is crenate; 6, the fruit bears hard pyrenes; 7, the cultivated forms when fully ripe are yellow within and sweet.



Spondias lakonensis, cultivated at Lao Cai near the Vietnam-China border. (Photographs © Mr. Chuah Hock Seong, Singapore.)

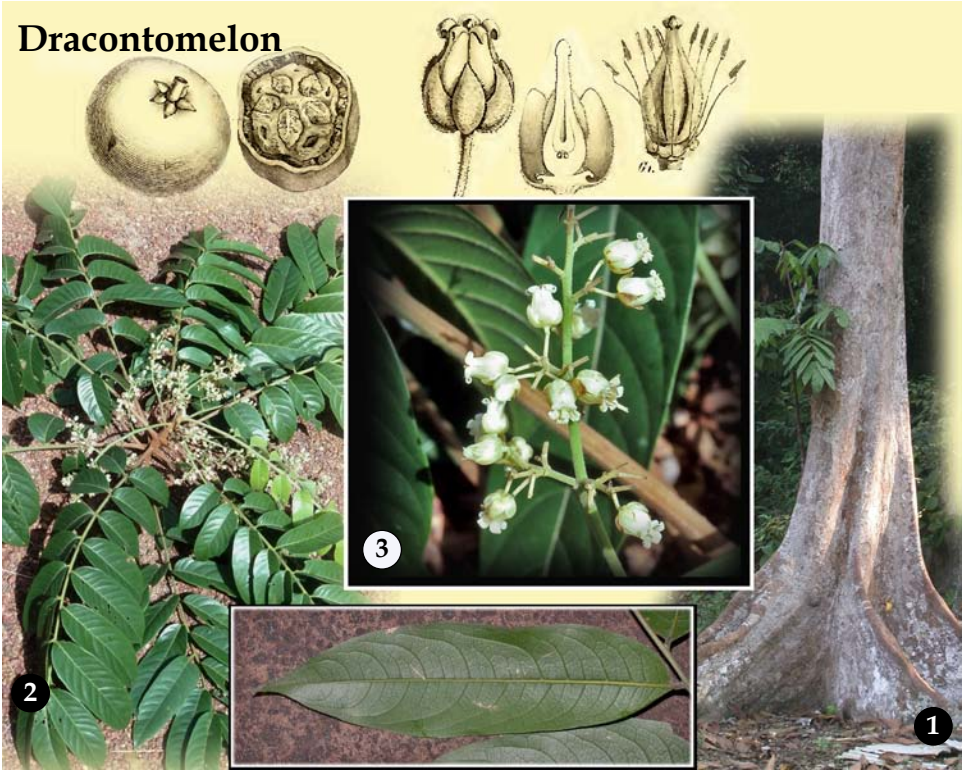
native species of *Spondias* are common in seasonal forests, uncommon in the everwet equatorial lands.

Two Neotropical species are widely cultivated. Perhaps most common is *Spondias purpurea* from Mexico and Meso-America, known as *sineguelas* and *seguelas* in the Philippines, sometimes in Malay as *kedondong*. This is among the most readily propagated of all trees. Even a branch as large as 10-15 cm across will strike roots when cut and planted. Consequently, many of the trees in the Philippines appear to be clonal. The other Neotropical species is the occasionally cultivated *Spondias mombin*. Among the native species, *Spondias cytherea* is the oldest name, with *S. dulcis* in synonymy; likewise *S. pinnata*, sometimes segregated. The entire genus needs a new molecular-based review.

DRACONTOMELON. [Greek, snake-fruit, perhaps in reference to the markings on the fruit.] South Asia to Pacific Islands. Maybe two species in the islands of tropical Asia, maybe five on Mainland SE Asia. All medium trees to 35 m in height but sometimes of large diameter, with great sweeping plank buttresses, as in *Dracontomelon dao*, or in the case of the Philippine *D. edulis*, without buttresses.

The flowers are small, to 10 mm long, but showy and fragrant. They are bisexual, with parts in fives, stamens 10, the epipetalous stamens shorter than those alternate,

Dracontomelon



Dracontomelon. 1-3, *D. dao*, Pasoh, Malaya; 1, trunk, with smooth gray bark and wide spreading buttresses; 2, clusters of long compound pinnately compound leaves; 3, flowers, white, urceolate, with reflexed corolla tips; above, drawing of flower and fruit; below center, leaflet of *D. mangiferum* from Vietnam. (Drawing adapted from BLUME *loc. cit.*)

the fruit to four cm across, yellow, with a single seed. Edible but usually of indifferent quality.

The usual Malay name is *senkuang* or *unkawang*, derived from Malay for the Argus Pheasant, in reference to the five markings on the fruit that resemble the markings on the feathers of that bird. But the name *dao* is also well-known, especially in the Philippines.

KOORDERSIODENDRON. [Commemorates SH Koorders, d. 1919, Dutch forester based in Bogor.] A single species, *Koordersiodendron pinnatum*, but an ecologically significant species. In East Borneo the tree is known by a wide variety of vernacular names with *rang-gu* fairly standard, although that is a name also applied to the unrelated *Azadirachta* (Meliaceae). In the seasonal parts of the Philippines, this tree is well known as *amugis*. It is also found east in Sulawesi and New Guinea. The bark is distinctive, nearly black and deeply furrowed, whereas the canopy is composed of dense but feathery clusters of long compound leaves. This is a deciduous tree with small *Spondias*-like fruit, much sought after by macaques. The ecology is poorly explored, but the dis-

tribution would appear restricted to regions in eastern tropical Asia with strong and regular dry seasons.

Koordersiodendron



Koordersiodendron pinnatum. Palawan Isl., Philippines, characteristic bark, dark and deeply fissured, the leaves feathery pinnately compound, in dense clusters; inset of tree with new leaf flush at Mt. Makiling, Luzon.

*Kostermans, A. 1991. Kedondon, Amborela, Amra. The Spondiaceae (Anacardiaceae) in Asia and the Pacific Area. 100 pages. Privately published in Bogor.



Choerospondias axillaris. 1-3, from Khao Yai National Park, Thailand; 1, mature tree; 2, young fruit; 3, mature fruit and large seed surrounded by white fleshy pulp and thin outer fruit wall; 4-5, from southern Vietnam; 4, bark of a mature tree; 5, leaf of a sapling. (Photographs 1-3, © Dr. Warren Brockelman.)

CHOEROSPONDIAS. [Greek, waxy *Spondias*.]

Another monotypic genus, represented by *Choerospondias axillaris*. This is an ecologically important tree of the strongly seasonal forests of India, S China and Mainland SE Asia. It reaches about 25 m in height, the mature bark gray with vertical cracks and sinuous fissures; the leaf with about eight pairs of leaflets and a well-stalked terminal leaflet; the lateral leaflets are stalked, the blade elliptic, the margin can be coarsely dentate or entire and the leaf stalks are sometimes short. Dense panicles of unisexual flowers form behind the leaves. The pistillate flowers are solitary and bear a five-locular ovary with one pendulous ovule per locule and five styles (compared to the single style in *Spondias*). The staminate flowers bear 10 stamens. The fruit is a drupe about three cm long, flattened at the ends, yellow, with a sweet edible flesh. The fruit are said to drop immediately upon ripening and thereby find preferred dispersers among the ground mammals rather than the arboreal species.

PLEIOGYNIUM. Maybe three species, essentially Pacific, especially the cultivated *P. cerasiferum* of Tonga, etc. Of trees native to the region, we have only *Pleiogygium timoriense* of the Lesser Sunda Islands, Sulawesi and New Guinea; sparsely collected in the Philippines and with one collection from Borneo. (Not illustrated.)

LANNEA. [Probably from a Senegal vernacular name for one of the many African species.] Africa, with one species to the east, *Lannea coromandelica*, the wodier tree, often under the synonym *Lannea woodier*, a species well illustrated in GARDNER *loc. cit.* While certainly native to India, and to be found south and east in the dry seasonal lands, including parts of Java, the natural distribution is complicated by cultivation and the ease with which the tree appears to naturalize in degraded sites. The tree is wholly deciduous, the flowers unisexual, the trees dioecious. (Not illustrated.)

SAPINDACEAE

NAME: From the genus *Sapindus*, which in turn was coined from *Sapo-indicus*, the Indian soap berry tree, in reference to the use made of the seed. Do not confuse the name with Sapotaceae, nor with any reference to 'sap', because our trees are without significant exudates. While the Sapindaceae are indeed rich in the class of chemicals called saponins, those constituents take their name not from here, but from the unrelated genus *Saponaria* (Caryophyllaceae). In English, these trees comprise the Soapberry or Lychee family. The family as a whole has no common name in Asia, although many individual species are well known and named as below.

OVERVIEW: A family of 135 genera and 1580 species, generally world-wide but especially from the equator northward to the subtropics of the Northern Hemisphere. The typical species is a small to medium tree with fine gray bark, somewhat hoop-marked, with no exudate (or a little thin whitish liquid in the trunk), rosettes of pinnately compound leaves with the leaflets shortly stalked and subopposite in arrangement, lacking a terminal leaflet, but with the naked rachis tip slightly exerted. The twigs bear dense axillary panicles of unisexual flowers, most of which are staminate and a few of which are pistillate, bearing a three-locular ovary of which one, two or three locules develop as a fruit of varying form. However, in every detail of form the family is highly variable. The leaf may be simple or trifoliate; when pinnate the rachis may be simple or winged, the leaflets may be hairy (simple or stellate) or glabrous, entire margins or toothed, with or without laminar glands and axillary domatia, and with or without a pair of basal leaflets as stipule-like organs; the calyx may be cup-shaped, with valvate members, or overlapping, the petals may be absent, ordinarily oval or spoon-shaped or densely hairy with glandular elaborations as a crest; the glandular disc may be entire and doughnut shaped, or deeply lobed or nearly absent; the stamens are variously short of long, with or without pollen, the style variously long or short, the stigma lobed or short entire, while the fruit may be a dry indehiscent berry, a pair of dry broadly winged samaras, or a fleshy berry with or without an aril that may or may not be strongly bound to the seed.

With that extensive range of variation, the combinations are almost endless. Consequently, while it is not too hard to identify individual species if you have complete floral and fruiting material and a key to local species, we find a great problem in placing the species in related groups. Nearly half of the 135 or so genera are

monotypic. This is true locally as well as globally. For example, in the highly competent treatment of the family for the *Tree Flora of Sabah and Sarawak*¹ we find 23 genera of which 10 genera have a single species while another six genera have but two species.

Despite the heterogeneity of form, molecular evidence supports monophyly for a broad Sapindaceae that includes the maples (the former Aceraceae) and buckeyes (Hippocastanaceae) and the eccentric genus *Xanthoceras*^{2,3}. Here I follow the suggested arrangement of Buerki *et al.*³ of four subfamilies: a monotypic Xanthoceroideae; Hippocastanoideae represented by the maples and buckeyes; a more narrowly defined Dodonaeoideae; and the Sapindoideae which is further divided among ten constituent clades.

In tropical America, the Sapindaceae are one of the principle families of woody climbers. The lianas include eight genera of the *Paulinia* clade which typically represent nearly a one-third of the species of the Sapindaceae in any Neotropical forest. In Asia, we find lianas represented solely by herbaceous climbing plant *Cardiospermum*. Otherwise, our representatives are entirely small trees and shrubs. In stature, the Sapindaceae differ from the Anacardiaceae, the Burseraceae and the Meliaceae in that they are rarely found in the upper canopy of the lowland equatorial forest. Even when the diameter is large, these are typically short trees. The rambutans reach a maximum DBH of between 40-50 cm. The largest diameters are probably found in *Pometia* which sometimes exceeds 100 cm DBH, but even then it is not a tall tree.

Growth rates vary widely by species. Among forest species, some *Nephelium* show relatively fast growth of about five mm DBH per year, whereas *Xerospermum* typically grows no faster than 1-2 mm per year.

Sapindaceae are among the most productive of trees with regard to fruit and saplings and it is never surprising to find that a member of the family is the most abundant of species in any forest survey.

Gaining a familiarity with Sapindaceae is not easy. The combined treatments for Sabah and Sarawak and for Thailand give a good regional guide^{3,4}. As a starting point, you might go out and examine the following genera, which are relatively easy to find and represent the main clades: *Acer laurinum*, *Harpullia*, *Lepisanthes*,

FIELD RECOGNITION: SAPINDACEAE

Trees of small to medium stature, buttresses small or absent, the bark gray, thin, hard, often with hoops, no exudate, rarely any odor, hard white wood.

Most of our genera with spirally arranged, pinnately compound leaves, leaflets subopposite without a terminal leaflet, but the last leaflet often subtends a short blunt or sharp point.

'Stipules' in *Pometia* and a few species of *Lepisanthes*.

Leaflet margin entire, or with teeth in *Pometia* and *Allophylus*.

The fine venation is often prominent when dry.

FIELD CONFUSION

Legumes: see especially *Dialium*.

¹Adema, F. *et al.* 1996. *Tree Flora of Sabah and Sarawak*. 2: 263-374.

²Harrington, M. *et al.* 2005. *Systematic Botany*. 30: 366-382.

³Buerki, S. *et al.* 2009. *Molecular Phylogenetics and Evolution*. 51: 238-258.

⁴van Welzen, P. 1999. *Flora of Thailand*. 7: 169-250.

Sapindaceae


XXXV.



Sapindaceae from VIDAL *loc. cit.*, Plate 33. Nomenclature follows MERRILL *loc. cit.* A, *Dodonea viscosa*; B, *Harpullia cupanioides*; C, *Tristiria triptera*; D, *Arytera livoralis*; E, cannot be identified; F, *Cubilia cubili*; (G, was *Turpinia pomifera* and was wrongly in the Sapindaceae); H, *Lepisanthes rubiginosa*; I, *Litchi chinensis*.

Phylogeny of Sapindaceae

The following arrangement follows the recommendations of Buerki *et al* as cited in the family introduction. All subfamilies and informal groups are listed, a preferred local name based on our more common genera is given together with the name used in Buerki given parenthetically. The global diversity and distribution is given in the last column with representation of genera within our region separated by a dash. A question mark precedes those genera for which molecular evidence is wanting, their position follows the traditional morphologically based tribal position.

Subfamily	Informal Group	Diversity, Distribution & Trees of Tropical Asia
 Xanthoceroideae		1/1 S China ---- 0.
Hippocastanoideae		5/129, N Temperate ---- 2/5, <i>Acer</i> , <i>Aesculus</i> .
Dodoneaeoideae	<i>Filicium</i> Group (<i>Doratoxylon</i> Group)	Africa, Madagascar to Australasia ---- 2/4, strongly dry seasonal, indehiscent fruit; <i>Filicium</i> , <i>Ganophyllum</i> .
	<i>Harpullia</i> Group (<i>Dodonaea</i> Group)	S America, Madagascar Australasia ---- 4/8, dry seasonal, dehiscent fruit; <i>Harpullia</i> , <i>Arfeuillea</i> , <i>Euphorianthus</i> , <i>Dodonaea</i> .
Sapindoideae	<i>Delavaya</i> Group	1/2, S China ---- 1/1, <i>Delavaya</i> .
	<i>Koelreuteria</i> Group	3/6 ---- 1/1 <i>Boniodendron</i> .
	<i>Schleichera</i> Group	3/8, ---- 3/5, <i>Schleichera</i> , <i>Paranephelium</i> , <i>Amesiodendron</i> .
	<i>Litchi</i> Group	8/75, India to Pacific, --- <i>Litchi</i> , <i>Pometia</i> , <i>Nephelium</i> , <i>Dimocarpus</i> , <i>Xerospermum</i> , <i>Cubilia</i> , <i>Glenniea</i> , <i>Lepidopetalum</i> .
		17/190, chiefly Paleotropical ---- <i>Lepisanthes</i> , <i>Atalaya</i> , <i>Sapindus</i> , ?- <i>Tristira</i> , ?- <i>Zollingeria</i> .
	<i>Macphersonia</i> Group	8 genera, Africa, Madagascar ---- 0.
	<i>Cupania</i> Group	30/450 pantropical ---- 12/20, dry seasonal forest, <i>Alectryon</i> , <i>Elatostachys</i> , <i>Guioa</i> , <i>Arytera</i> , <i>Mischocarpus</i> , <i>Trigonachras</i> , <i>Diploglottis</i> , <i>Rhysotechia</i> , ?- <i>Gloeocarpus</i> , ?- <i>Gongrospermum</i> , ?- <i>Pavieasia</i> , ?- <i>Sisyrolepis</i> .
	<i>Tristiriopsis</i> Group	2/6 Asia, Pacific, ---- 2/4, <i>Tristiriopsis</i> , <i>Dictyoneura</i> .
	<i>Blomia</i> Group	2/2, Mexico, ---- 0.
	<i>Melicoccus</i> Group	2/62, Neotropics ---- 0.
	<i>Paullinia</i> Group	14/750, chiefly S America, especially lianas ---- 1/15, <i>Allophylus</i> .

Nephelium and *Pometia*, then probably *Guioa*, and finally *Allophylus*.

☞ - Subfamily Hippocastanoideae - ☞

ACER. [The classical name of the European maple.] *Acer* is the maple genus, with 111 species, well-known and with an extensive literature concerning the numerous species of the N Temperate latitudes, especially E Asia and E North America. The few species of tropical Asia are not so well examined.

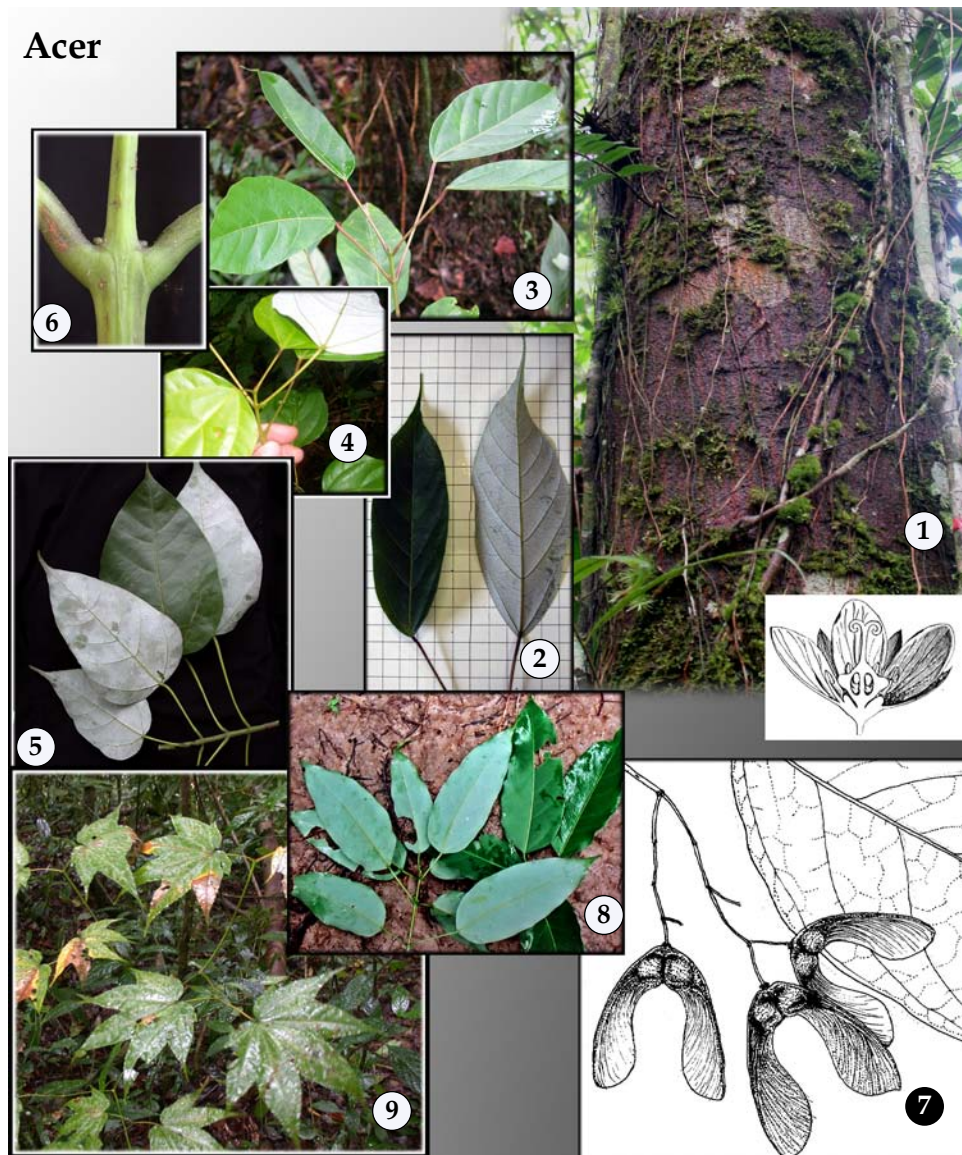
Most maples have opposite leaves with long unswoollen leaf stalks, a palmately nerved blade, or at least three-nerved at the base. Most of the temperate maples are wind-pollinated. Can the same be said of the tropical maples? They are dioecious and bloom in the driest months of the year. But the same is true of the oaks, and these tend to be insect-pollinated in our area in contrast to their Temperate Zone relatives.

Acer laurinum is the sole species found in most of tropical Asia, scattered, sometimes patchily abundant

at 1000-1500 m in places with strong dry seasonal climates, and in variant forms. Names now synonymized include *A. caesium*, *A. niveum*, and *A. philippinum*. Thick low buttresses, a gray smooth to cracked bark, a strongly deciduous species that sprouts leafy twigs and inflorescences early in the dry season. The distribution includes most of the mountains of the Philippines, Sulawesi and Timor, Java and Sumatra, and the Main Range of Malaya. Considered a rare species in the aseasonal forests of Malaya and Borneo, but it may simply be overlooked. In Borneo, it is known from Kinabalu, it was collected a few times in Sarawak, and may well be found in low density in many mountains over 1000 m. This species was curiously twice collected in peat swamps in the southern Malay Peninsula, and is noted by MERILL *loc. cit.* as occurring at low elevations on basalt in Basilan. If treated in the broadest sense, then it is also found northward and west to Vietnam, N Thailand and India.

Additionally we find four species of *Acer* in the mountains of N Thailand, Laos, Vietnam, and tropical

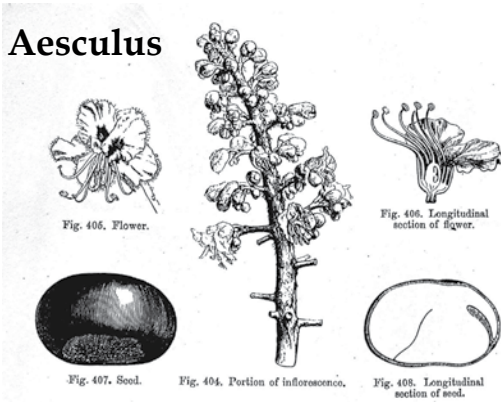
Acer



Acer. 1-6, *A. laurinum*, from various montane sites in tropical Asia; note the opposite leaves, 3-nerved base, white lower surface; 1-3 from Gunung Halimun, west Java, Indonesia, at 1100 m elevation; 4, on Mt. Nug-as, Cebu Island, Philippines, at about 800 m elevation; 5-6, in the Central Highlands, Vietnam, at about 1400 m elevation; 7-8, *A. oblongum* from Huai Kha Khaeng, Thailand, where it is abundant on damp ground at only 500 m elevation; 7, the characteristic fruit; 8, the leaves; 9, *Acer* sapling, not identified to species, 1800 m elevation in the central Highlands of Vietnam, with palmately nerved and deeply lobed leaves; 10, a drawing of a transverse section of a flower. (Photographs 1-3, © Professor Eizi Suzuki; 4, © Leonardo L. Co; drawing 7 from BUNYAVEJCHEWIN *loc. cit.*; 11, adapted from BAILLON *loc. cit.*)

Myanmar. *Acer oblongum* is widespread and in places abundant, especially in riverine or alluvial forests, from 2000 m elevation in the Himalayas and Nepal, east and south as far as central Thailand and Indochina at 500-1000 m. It is a canopy tree, to 25 m height, the bark gray, smooth with irregular horizontal wrinkles, the base of the trunk with small round buttresses. The blade is

unlobed, the basal nerves are relatively weak, widely spreading. A deciduous tree, the flowers emerge annually just before the new leaves. Also in the mountains of Thailand, Laos and Vietnam we find several species with leaves that are palmately nerved and lobed three to seven times. *A. lanceolatum* and *A. laevigatum* are illustrated in THROWER *loc. cit.*



Aesculus hippocastanum, drawing of floral details, adapted from BAILLON *loc. cit.*

AESCULUS. [Classical name for an unrelated nut tree.] These are the Horse Chestnuts or Buckeyes of Europe and America, with about 15 species in the northern latitudes and one, *Aesculus assamica*, extending into the Asian tropics in Thailand, Laos and at least northern Vietnam if not the Central Highlands. If you get to see *Aesculus*, you can quickly recognize it by the opposite palmately lobed to compound leaves and the stiff erect white flowered spikes. The fruits are capsules that split to



Ganophyllum falcatum, illustration from Brown, W. Minor Forest Products of the Philippines.



Filicium decipiens. The fern-tree is chiefly found in tropical Asia as a cultivated plant, easily recognized by the deep green foliage with the wide winged rachis. Drawing from BRANDIS *loc. cit.*

reveal a single large black seed. Note that several invalid and superfluous names were published in the 1960s and these are sometimes still used in regional literature.

☞ - Subfamily Dodonoideae - ☞

A - *Filicium* Group - a

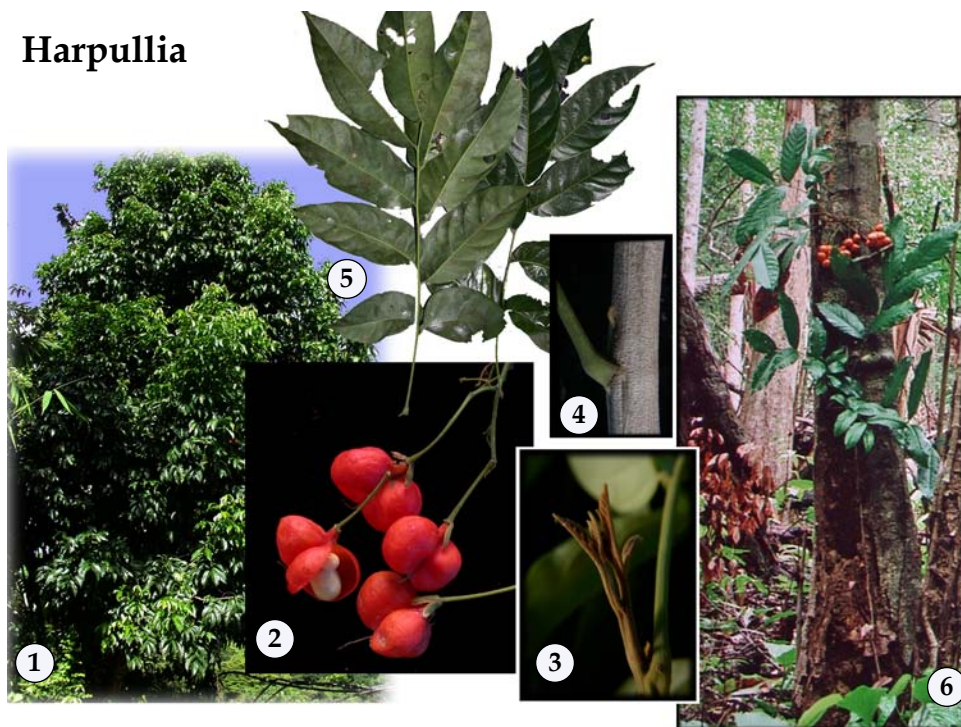
FILICIUM. [After the somewhat fern-like leaves.] Maybe six species, chiefly Africa, with *Filicium decipiens*, the fern-tree, native to Africa, India and Sri Lanka, but cultivated everywhere.

GANOPHYLLUM. [Greek, bright-leaf.] Two species, one in West Africa (or segregated as another genus), and one, *Ganophyllum falcatum*, found in tropical Asia, from the Andaman Islands east (sparsely in Malaya, uncommon in Sabah) to Australia and the Pacific. Perhaps chiefly in coastal forests of dry seasonal climates. (Not illustrated.)

A - *Harpullia* Group - a

HARPULLIA. [From a Bengal name for one of the species.] A genus of tropical Asia with 26 species found

Harpullia



Harpullia arborea. 1-5, Luzon, Philippines; 1, habit as a small tree with dense crowded foliage; 2, the red dehiscent capsules; 3, twig apex; 4, the node; 5, pinnately compound leaves; 6, a forest tree in Huai Kha Khaeng, Thailand, with large fruit.

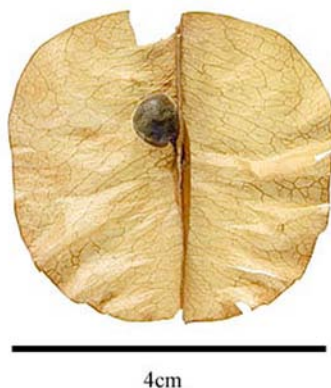
from Sri Lanka to the Pacific. These are small and medium sized trees, sometimes reaching 50 cm DBH, but never very tall. The lower surface bears tufts of simple hairs, leaves with one-nine pairs of leaflets, the flowers unisexual, sepals five, petals five, stamens five-eight, pistil two or three locular, ovary sessile, one or two ovules per locule, fruits are capsules of two or three lobes that open to expose the arillate seeds.

Harpullia arborea is perhaps the most common species, found all around tropical Asia, but an abundant member of the forest flora only in strongly seasonal places. It differs from the other species in that the sepals fall away early, the petals are easily pulled out and bear a pair of lobes at the base, the aril is a small ring around the hilum.

ARFEUILLEA. Monotypic, *Arfeuillea arborescens*, the Hop Tree of open dry seasonal forests of Mainland SE Asia, notable for the wind-dispersed winged single-seeded fruit. This small tree is widely though sparsely cultivated in Asia; it is often mentioned among the more popular medicinal plants of Thailand.

EUPHORIANTHUS. [Greek, full of flowers.] Monotypic: *Euphorianthus euneurus*, E Indonesia, from Sulawesi and Muluka. Large leaves with large thick leaflets, and a smooth indehiscent fruit. (Not illustrated.)

Arfeuillea



Arfeuillea arborescens, the single seeded winged fruit; photograph from the USDA-GRIN database.

DODONAEA. [Commemorates Rembert Dodoens d. 1585, Dutch herbalist.] A genus of 68 species, chiefly Australian, where 59 endemics are found, and a few to the Pacific and New Guinea with a single pantropical lit-



Schleicheria oleosa, illustration adapted from Brandis, *Illustrations of the Forest Flora of North-West and Central India*, 1874.



Paraneupheliium xestophyllum, a voucher specimen from Pasoh, Malaya, shiny dry leaves and small warty fruit.

toral, *Dodonaea viscosa*, found scattered everywhere on sandy coasts. In most of tropical Asia, this is the only Sapindaceae with simple leaves. (Illustrated in the plate of Sapindaceae fruit diversity.)

♂ - Subfamily Sapindoideae - ♂

A - Delavaya Group - a

DELAVAYA. [Commemorates Père Delavay, d. 1895 in Yunnan, extraordinary plant collector, over 200,000 collections, including the type specimen of this genus.] A single species, *Delavaya toxocarpa*, (= *D. yunnanensis*) known from SW China to Northern Vietnam and Laos. Differs from *Harpullia* in that the leaf is reduced to a terminal leaflet and one lateral pair, the capsule wall is hard, colored bright purple, the seeds lack an aril. (Not illustrated.)

A - Koelreutia Group - a

BONIODENDRON. [Commemorates Henri François Bon, d. 1894, French cleric and botanist who collected in Indochina.] Two species, *Boniodendron minus* in China (sometimes segregated as *Sinoradlkofera minor*), and *Boniodendron parviflorum* in northern Vietnam. Small evergreen trees with leaves alternate, paripinnate, exstipulate; leaflets alternate or subopposite, base asymmetric, margin serrate. Flowers unisexual, sepals five, overlapping;; petals five, longer than sepals, obovate or oblong, clawed, each side with one ear-like scale at the base. Male flowers with eight stamens. Capsules three-winged with one seed per locule. (Not illustrated.)

A - Schleicheria Group - a

SCHLEICHERA. Monotypic, *Schleicheria oleosa*, Sri Lanka, India, Mainland SE Asia, Java and SW Sulawesi, and also widely cultivated, MERRILL *loc. cit.* excluded it as a native Philippine plant, but it is widely if sparsely cultivated.

PARANEPHELIUM. [Greek, near to *Nepheium*.] A genus of four species found rarely but widely in tropical Asia, especially *Paraneupheliium xestophyllum*, typically with two pairs of strictly opposite leaflets and a terminal leaflet, monoecious, a small warty fruit that bears a single seed without an aril.

AMESIODENDRON. [Commemorates Harvard orchidologist Oakes Ames, d. 1950.] One species, *Amesiodendron chinense*, (formerly *Paraneupheliium chinense*) S China to Mainland SE Asia as far south as Selangor in the Malay Peninsula, and Aceh in Sumatra. Differs from *Paraneupheliium* in the imparipinnate leaves, the fruit divides into pieces. Trees, 5-25 m tall. Bark dark gray,

Litchi



Litchi chinensis. drawing of habit, staminate and pistillate flowers; inset shows the lower leaf surface, glaucous with finely boxed veins; unlike *Nephelium*, the fleshy aril of *Litchi* pulls away freely from the shiny brown seed. (Drawing from BAILLON *loc. cit.*)

nearly smooth; branches dark reddish brown, strong, stout, shallowly furrowed, pubescent. (Not illustrated, but a photograph of the leaves is found at the *Flora of Peninsular Malaysia On-Line*.)

A - Litchi Group - a

LITCHI. [From the Chinese name.] One species, *Litchi chinensis*, the well-known fruit tree, lychee, possibly originating in northern Vietnam but the natural distribution is uncertain. On the one hand, we have the subtropical cultivated tree centered in S China and Vietnam; on the other hand, we find wild trees scattered here and there in tropical Asia, including individuals in the Malayan Main Range and in the more dry-seasonal parts of lowland Borneo and Philippines, the latter sometimes called *L. philippinensis*. This well-known species has been in cultivation for more than 1500 years. The fresh and dried fruit are exported in large numbers around the world.

The trees in the field can usually be recognized by the fallen leaflets, smooth glossy red above with a sharply sunken midrib, and a white lower surface with obscure net-like venation. The juvenile leaflets are much larger and venation more prominent. Molecular data might help clarify the variation within lychee.

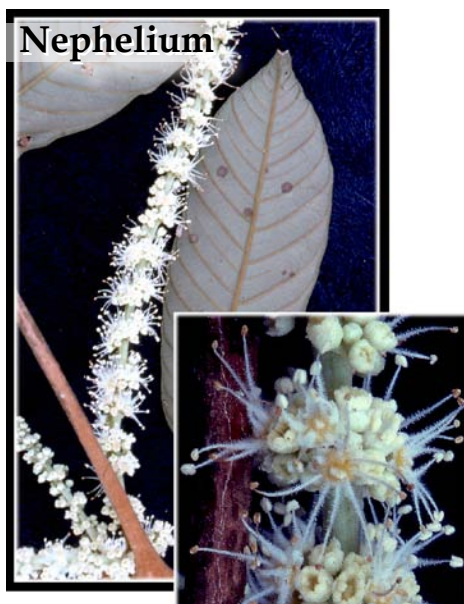
NEPHELIUM. [Greek, cloud, perhaps in reference to the dense clusters of very small flowers.] *Nephelium* is a core genus of those Sapindaceae of lowland equatorial

forest, with an estimated 22 species, found from Mainland SE Asia to Maluku. The most widespread common name is rambutan, from the Malay *rambut* for hair. The diversity of local names for village and jungle fruit is very great. Iban generally refer to rambutans as *sibau*, but there are again many local types and local names.

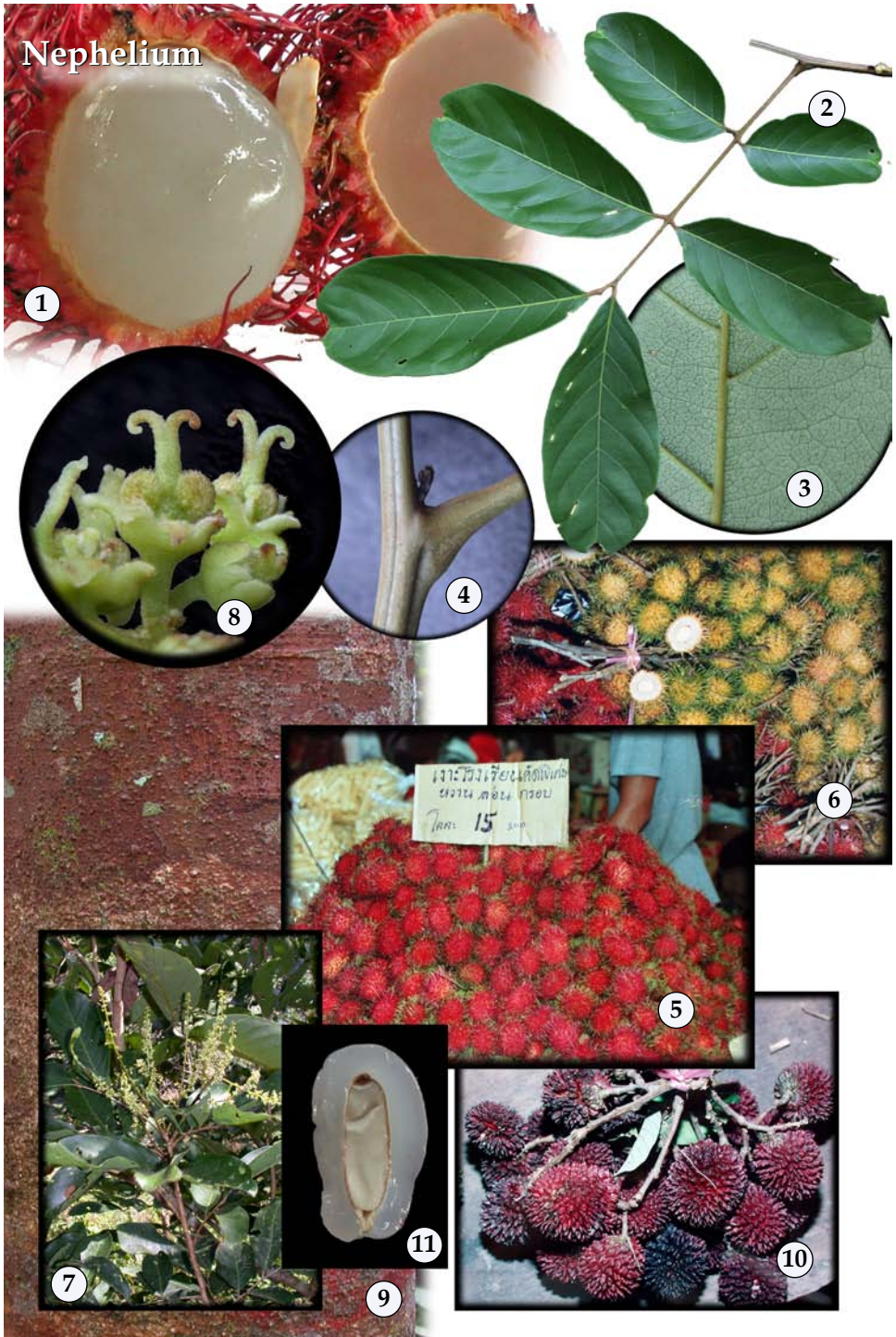
Most *rambutans* share compound leaves with alternately arranged leaflets that are pale beneath with very fine reticulate venation. All species bear edible fruit. Sexuality varies in ways characteristic of the family: some trees bear only male flowers, other mixed inflorescences. Diversity is centered in Borneo and it is there that the confusion of species will have to be sorted out. Northward into the Philippines, *Nephelium* is poor in species, although still plentiful in abundance.

The two most popular cultivated species are the common rambutan itself, *N. lappaceum* and *N. ramboutan-ake*, the latter is usu-

ally called *pulasan* in Malay. In their extreme cultivated forms, the two are readily distinguished. The *pulasan* differs in the short stumpy spines broad at the base, a crisp purple outer wall and a tangy flavor of blackberries.



Nephelium ophioides, Pasoh, Malaya, a staminate tree, or mostly staminate inflorescence.



Nephelium. 1-8 *N. lappaceum*; 1, fruit with fleshy aril attached to fibrous endocarp; 2, leaf; 3, lower surface of leaflet, glaucous, typical venation, axillary domatia; 4, twig with ridges and leaf base; 5, rambutan in Thailand; 6, yellow form of rambutan in Sarawak; 7, inflorescence; 8, pistillate flower, 2-lobed ovary, long spreading stigma, small or absent staminodes; 9, *N. maingayi* bark, reddish, warty lenticellate; 10, fruit of *N. ramboutan-ake*, the Malaysian *pulasan*, Sarawak; 11, transverse view of the seed and aril.

However, the wild forest trees are not so easily segregated and research is still required to discern the history and distribution of these common fruit trees.

POMETIA. [Commemorates P. Pomet, d. 1699, French scientist, author of *A Compleat History of Drugs*.] Currently treated as one variable species, *P. pinnata*, found widely in the warm parts of Asia and throughout the Pacific Islands. The tree is generally constant in the mottled orange and white bark, the habit of compound leaves that flush in bright red clusters, the thick twigs with clasping stipule-like leaflets, and in the smooth green-yellow fruit with thin sweet aril. Some eight or so forms or varieties are noted differing in the details of leaflet shape (especially margin entire or deeply toothed), in the development of buttresses, and in the size of the fruit. These are typically trees of stream and river banks but with a wide ecological amplitude as would be expected with such a wide geographic range. The fruit of *Pometia* is hardly comparable in quality to either the lychee or the rambutan and within the equatorial lands it is hardly ever sought out for consumption. However, it is gathered and eaten widely in the Polynesian Islands.

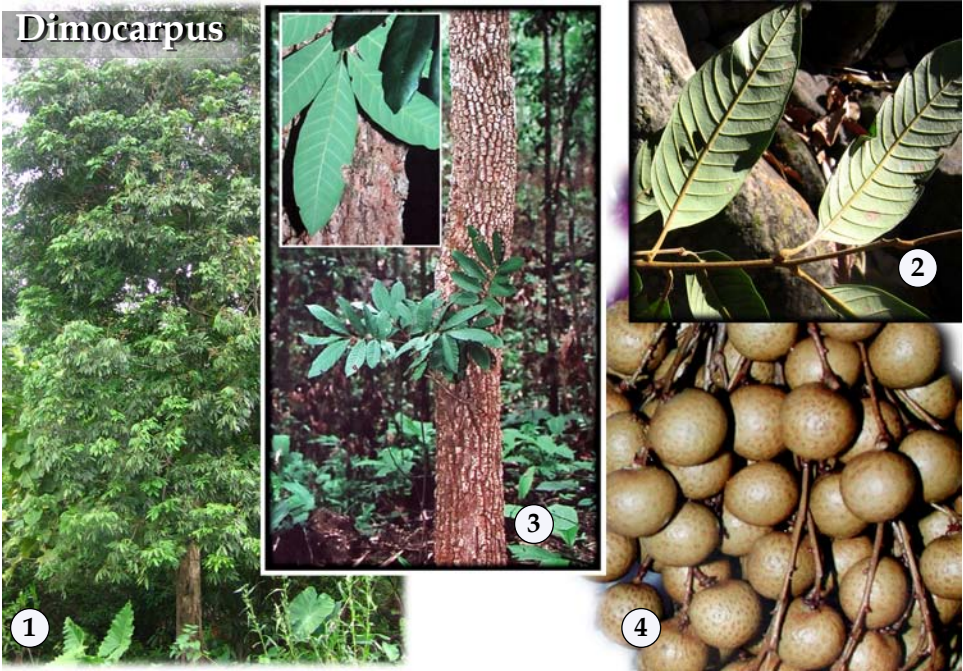
DIMOCARPUS. [Possibly from *dimorphos* and *carpus*, in reference to the two carpels.] A genus of six species, from Sri Lanka and India to Australia. The best known species is the wild and cultivated fruit tree, *Dimocarpus longan*, widely known as *longan* and *mata kuching*. The fruit differs from the fruit of *Nephelium* in that fleshy aril of the *longan* attaches to the seed only at a point near the base. In the rambutan, the sweet fleshy part is derived from the seed wall itself and so is never entirely free. This genus includes variation in characters that define other genera such as *Cubilia*.

XEROSPERMUM. [Greek, dry seed.] A genus of two species chiefly of the lowland forest of the Sundaic Region, but also extending northward to wet forests of Mainland SE Asia. The most common is *Xerospermum noronhianum*, the abundant and well known forest tree called *rambutan pacat* in Malay, or by the colorful *tundun biawak* in Iban. The leaf consists of two pairs of leaflets, opposite, each leaflet with several conspicuous glands in the blade.

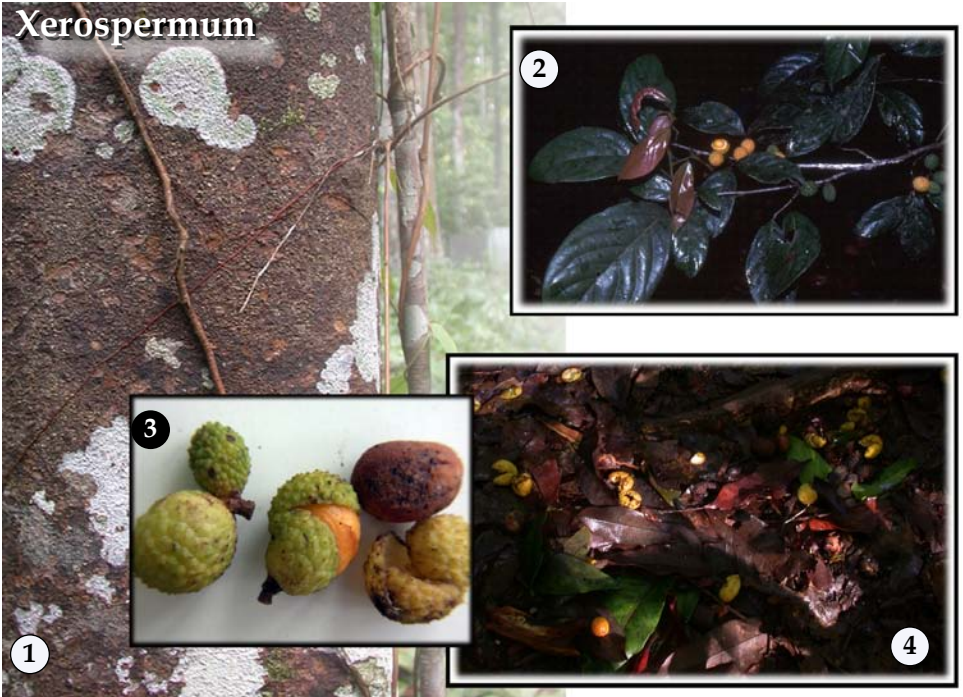
This was the most abundant species of tree in the 50-ha plot at Pasoh forest, and the only species to show a profound density-dependence. In those individual hect-



Pometia. 1-4, *P. pinnata*; 1, characteristic bole and bark, Pasoh, Malaya; 2, typical stream side habit, Philippines; 3, some forms of *P. pinnata* have leaflets with a toothed margin, here from eastern Luzon, Philippines; 4, some forms bears leaflets with entire margins, here from western Luzon, Philippines, the lowermost leaflets as stipules, note the swollen twig and leaf base. (Photograph 3 © Leonardo L. Co)



Dimocarpus. 1-4, *D. longan*; 1, cultivated tree, Philippines; 2, lower leaf surface; 3, wild tree with distinctive bark, among the most abundant species at Huai Kha Khaeng, Thailand, with inset showing the leaf; 4, mature fruit, from a market in Sarawak. (Photographs 1-2, © Ulysses Ferreras.)



Xerospermum. 1-4, *X. noronbium*; 1-2, Pasoh; 1, characteristic dark red and black bark with small round flakes that are colored orange-red; 2, the fruits remain green for nearly a month, then mature to yellow, Malaya; 3-4, southern Vietnam; 3, the fruits dehisce at maturity exposing the orange aril; 4, fruit scattered below a tree.

ares where the number of mature trees became relatively dense, recruitment of saplings dropped to nearly zero, this despite the many seedlings that would carpet the forest floor after a fruiting. The cause of seedling death around these mature trees was never determined, but a soil-borne pathogen was suspected. The very large and robust population data set at Pasoh has yet to be studied in any detail.

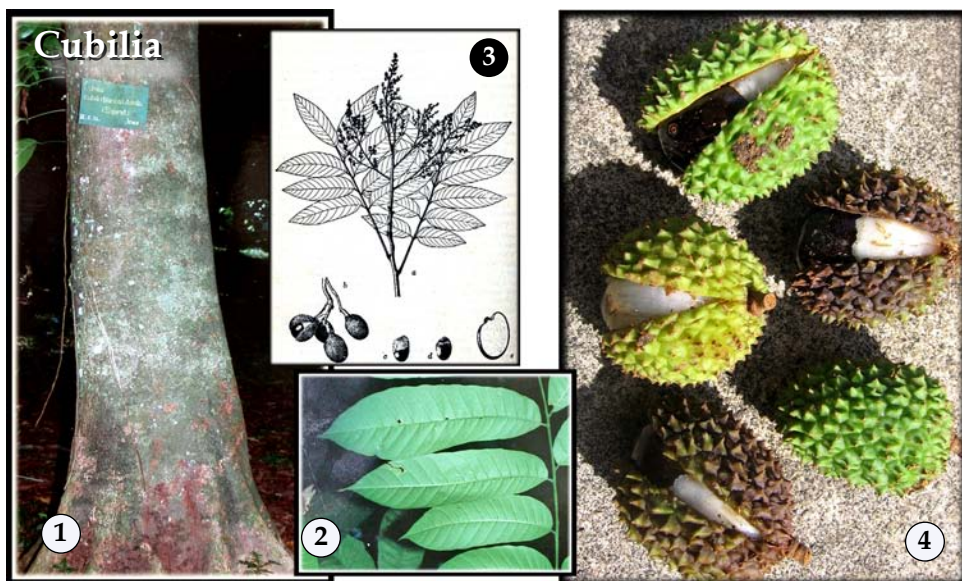
CUBILIA. [From *kubili*, a name in the Philippines.] A genus of a single species, *Cubilia cubili*, found in strongly seasonal parts of easternmost tropical Asia, from Luzon Island, Philippines south to eastern Borneo and Sulawesi.

GLENNIEA. [Named by JD Hooker, unspecified commemoration, possibly British naturalist Rev. J. Glen-nie.] eight species, three in Africa, three in tropical Asia. These are small trees of the lower canopy; the leaves bear tufted hair in nerve axils of the leaflets. The inflorescence is terminal, flowers unisexual, mixed in the inflorescence or on separate trees, sepals four or five, petals absent in our species, stamens four-eight, pistil sessile, two-locules in our species, fruit indehiscent, no aril. *Glenniea philippinensis* and *G. thorelii* are both from Mainland SE Asia and then disjunctly in the Philippines and east Borneo, while *G. penangensis* is endemic to Malaya, but wide-spread there.

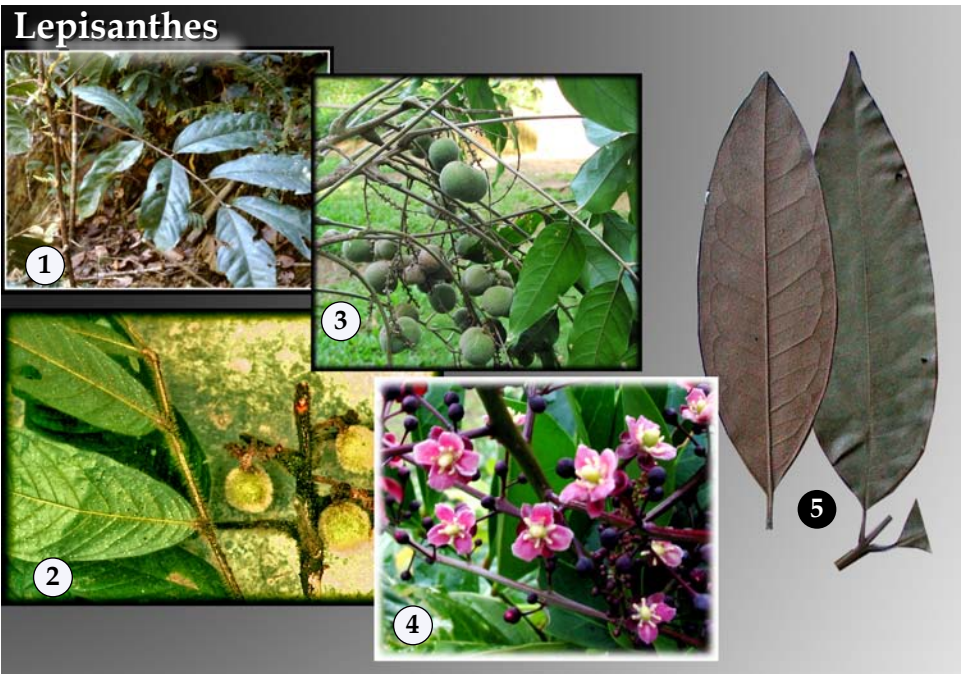
LEPIDOPETALUM. [Greek, scale-petal.] Six, Australia to New Guinea, two species westward to Andamans, Sumatra, and *Lepidopetalum perrottetii* in the



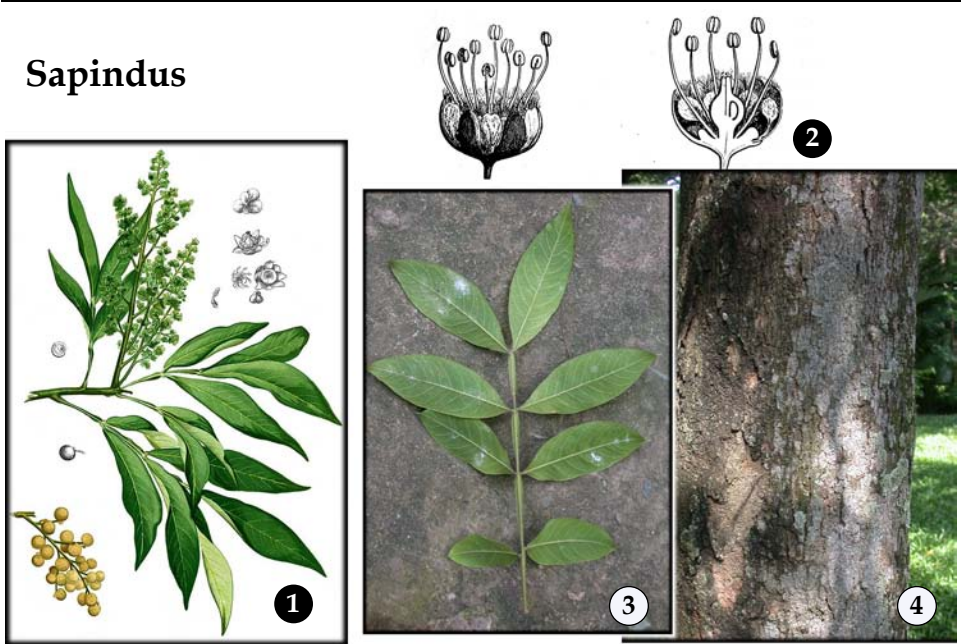
Glenniea. 1, *G. philippinensis*, drawing of habit and flower; 2, herbarium specimen of *G. thorelii*, Lambir, note leaf color and fruit. (Drawing adapted from BROWN *loc. cit.*)



Cubilia cubili, a Philippine endemic; 1-2, cultivated in the Bogor Botanic garden; 1, the form of the trunk and bark; 2, the leaflets; 3, drawing of habit, leaves and fruit; 4, the dehiscent fruit with the white aril variably covering the black seed, Bataan, Philippines. (Drawing from Brown, W, 1941, *Useful plants of the Philippines*. Department of Agriculture and Commerce; photograph 4 © Ulysses Ferreras.)



Lepisanthes. 1, *L. tetraphylla*, a common and abundant small tree of the forest understory, here at Pasoh, 1 cm DBH; 2, the densely hairy small tree *L. hirta*, sometimes treated as a variety of *L. tetraphylla*, at Pasoh; 3, a larger form of *L. tetraphylla* in fruit, from Isabela, Luzon, Philippines; 4, the flowers of *L. fruticosa*, from Palawan, Philippines; 5, the dry leaflets of *L. senegalensis*, showing the species-characteristic boxed and looped venation. (Photographs 3 & 4 © Leonardo L. Co.)



Sapindus. The examples here are from cultivated trees, and the names of these are by no means well established. 1-2, *S. indicus*; 3-4, a tree cultivated in the old Saigon Botanic Garden, Ho Chi Minh city, Vietnam, listed under the name *S. mukorossi*, but certainly different from the common application of that name in India. (1, adapted from BLANCO *loc. cit.*; 2, from BAILLON *loc. cit.*)

Philippines. These trees are not very well known within our region. The most recent molecular work cited in the introduction determines that they do not belong with *Cupania* where they have long been placed, but are rather related to the *Litchi* group. (Not illustrated.)

A - *Lepisanthes* Group - a

LEPISANTHES. [Greek. scale-flower, reference to the scales at the base of the petals] A genus now taken broadly to include the former genera *Aphania*, *Erioglossum*, and *Otophora*, and consequently somewhat heterogeneous, with 24 species from Africa to Australia. Mostly small trees, a few to the lower canopy. The leaf form varies: some with strictly opposite leaflets and a terminal leaflet, others with alternate leaflets, a few with slightly winged rachis. In many species the lowermost leaflets form a clasping type of 'stipule', this is most conspicuous in the abundant shrub *Lepisanthes tetraphylla*. Flowers unisexual, sepals four or five, usually unequal size, petals four or five, stamens about eight, ovary sessile, two or three celled, ovules one per cell, fruit variably lobed or not, not splitting, drupe like, seed without aril. *Lepisanthes senegalensis*, is a common medium-sized tree distinctive in the stiff leaflets with neatly looped venation.

ATALAYA. [From an Indian name.] 11 species from Africa to New Guinea and Australia where it is represented by nine species, eight of them endemic. Distinguished by the fruit with long wings, looking much like the fruit of *Acer*.

SAPINDUS. [From *sapo-indicus*, the Indian soap tree, in reference to the use made of the seed.] 10, Scattered globally in tropical and warm temperate. These are often cultivated, especially *Sapindus indicus*.

TRISTIRA. one, *Tristira triptera*, Philippines, Sulawesi, Maluku. (Not illustrated.)

ZOLLINGERIA. [Commemorates H. Zollinger, d. 1859, Swiss botanist and explorer of Indonesia.] Three, Thailand and Myanmar, one in Borneo. (Not illustrated.)

A - *Cupania* Group - a

A difficult group, including 14 genera here many uncommon and scattered, poorly resolved as to phylogeny.

PAVIEASIA. [Uncertain.] Three species, S China with one to N Vietnam, *Pavieasia annamensis*. (Not illustrated.)

GUIOA. [Commemorates J. Guio, 18th century Spanish botanist.] 65, Thailand, Malaysia, Borneo, to Pacific as far as Samoa, 13 in the Philippines. Small trees, leaves one-nine pairs, leaf stalk winged in some species, leaflets sessile, domatia as sacs or pockets in nerve axils, inflorescence a thyrses, flowers bisexual, sepals five, inner three with petaloid margin, petals five, those between the two larger sepals reduced, stamens eight, pistil three lobed, three locules, ovules one per

locule, fruit a one to three lobed capsule splitting open, seeds black, covered more or less by aril, dangling when mature.

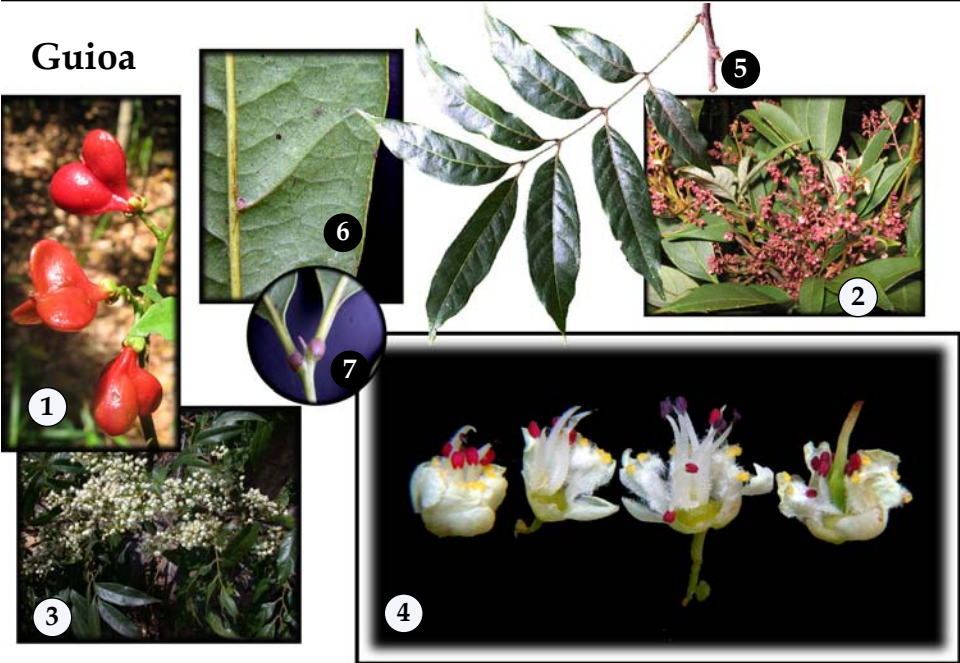
ARYTERA. [Greek, ladle, in reference to the shape of the fruit valves] 30, chiefly in New Guinea and Australia and several in the Pacific Islands. Most species have spreading fruit valves, mostly of the same shape and appearance, and most species bear two or four leaflets, strictly opposite, stiff, with strong arched nerves. Only one widespread species, *Arytera littoralis*, reaches so far west as Mainland SE Asia and NE India. This is a medium sized tree of evidently wide ecology, never especially common but unsurprising throughout tropical Asia. The bark is typical of Sapindaceae, gray and smooth, leaflets of two pairs (sometimes three), somewhat pendent. The general appearance of the leaf, though not the fruit, is as in *Xerospermum*, however the blade lacks laminar glands, and on the lower leaf surface the axils of the major nerves support woolly clusters of hair. The flowers are bisexual, about three mm across, sepals and petals five, stamens eight, ovary sessile, hairy three lobed, one ovule per locule, only two locules develop into a strongly two-lobed fruit. The capsule walls split to display the seed covered in the lower half by an aril (two-layer?) yellow and orange. Never wholly deciduous: new leaves flush in late dry season, the old leaves are shed about six months later.

ELATTOSTACHYS. [Greek, little-spike, reference to the inflorescence] 13 species, mainly east of Wallace's Line, one in the Philippines, *Elattostachys verrucosa*, also in E Indonesia, Australia and the Pacific. The fruit with woody valves, pink at the sutures, and simple raceme or panicle-like inflorescence. The leaves often dry black. (Not illustrated.)

ALECTRYON. [Greek, cock, in reference to the comb-like crest on the fruit of some species.] 20-30 species, chiefly Australia and the Pacific, a few species reach westwards to Indonesia with two in the Philippines: *Alectryon fuscus* of NW Luzon and the widespread and common *A. glaber*, found sparsely in coastal forests in dry seasonal places from Java eastward to New Guinea and North to the Philippines. The best characters are the paired opposite leaflets without a terminal leaflet, the leaflet margin with at least a few coarse teeth; the fruit are capsular, yellow with black seeds and red arils. Because of the fruit, it was traditionally allied with the rambutans, although segregated with those genera that have a dehiscent rather than indehiscent capsule. The molecular evidence (based on the Australian *A. connatus*) rejects that position while leaving a better placement unresolved.

MISCHOCARPUS. [Greek, stalked-fruit.] A genus of 15 species, nine of which are endemic to

Guioa



Guioa. 1, 3-7, *G. koelreuteria*, Philippines; 1, the flattened 3-lobed fruit characteristic of the genus; 2, *G. discolor*, Philippines, with bi-colored leaves, and dense inflorescence of pink flowers; 3, inflorescence; 4, flower with sepals, elaborate bifid petals, eight stamens of varying length, flattened ovary; 5, leaf; 6, lower leaflet surface with pocket axillary domatia; 7, compound leaf tip with slight extension beyond final leaflet, typical of family. (Photographs 1 & 2 © Ulysses Ferreras.)

Australia, and perhaps two common westward to Mainland SE Asia, India and southern China. The genus differs from other Sapindaceae in the unisexual flowers

(monoecious or dioecious), leaflets are more or less alternate, and the small well-stalked fruit as a capsule that splits as it dries and from which hangs the shiny brown seeds covered in a thin aril. The two most common species are *Mischocarpus pentapetalus* and *Mischocarpus sundauicus*. (Not illustrated.)



Guioa bijuga, dry herbarium voucher from Lambir, Sarawak, showing the contrasting black and red-gray leaf surfaces.

TRIGONACHRAS. [Greek, three-angled pear, in reference to the fruit.] eight species distributed from Malaya eastward to New Guinea. The illustrated leaf and fruit of *Trigonachras acuta* are typical of the genus.



Arytera littoralis, Huai Kha Khaeng, Thailand, an abundant small tree, the trunk 4 cm DBH, note the dehiscent fruit, the four leaflets are fairly consistent, the tree can be confused with *Xerospermum*, but the bark differs, the leaves without glands.



Diploglottis cunninghamii, an Australian species, with peculiar dehiscent fruit, sometimes cultivated; the color illustration from H.E. Baillon *Dictionnaire de Botanique*, 1886; drawing of flower from BAILLON *loc. cit.*

DIPLOGLOTTIS. [Greek, two-tongued, in reference to the two scales at the base of the petals.] 10 species, eight endemic to Australia, two west as far as Mainland SE Asia.

RHYSOTOECHIA. [Greek, in reference to the wrinkled inner side to the fruit wall.] The genus includes 14 species, chiefly Australia and westward to New Guinea, eastern Indonesia, east Borneo and the Philippines. Close to *Guioa*, differs in that the petals that lack scales (in some species only?). *Rhysotoechia ramiflora* is found in the Philippines.

GONGROSPERMUM. [Greek, swollen seed.] A monotypic genus, *GongrospERMUM philippinense*, from Luzon, Philippines. (Not illustrated.)

GLOEOCARPUS. [Greek, *gloios*, sticky fruit.] *Gloeocarpus patentivalvis* small tree of lower canopy, Philippines from Luzon to Mindanao. About 12 pair of nearly sessile leaflets, wavy margins, 'pocket domatia?' Inflorescence ramiflorous, flowers bisexual, zygomorphic, sepals five, petals, five, stamens seven, pistil three-locular, ovule one per locule, fruit usually three-lobed about 1.5 cm long, a capsule splitting when dry, black, aril covers the three seeds.

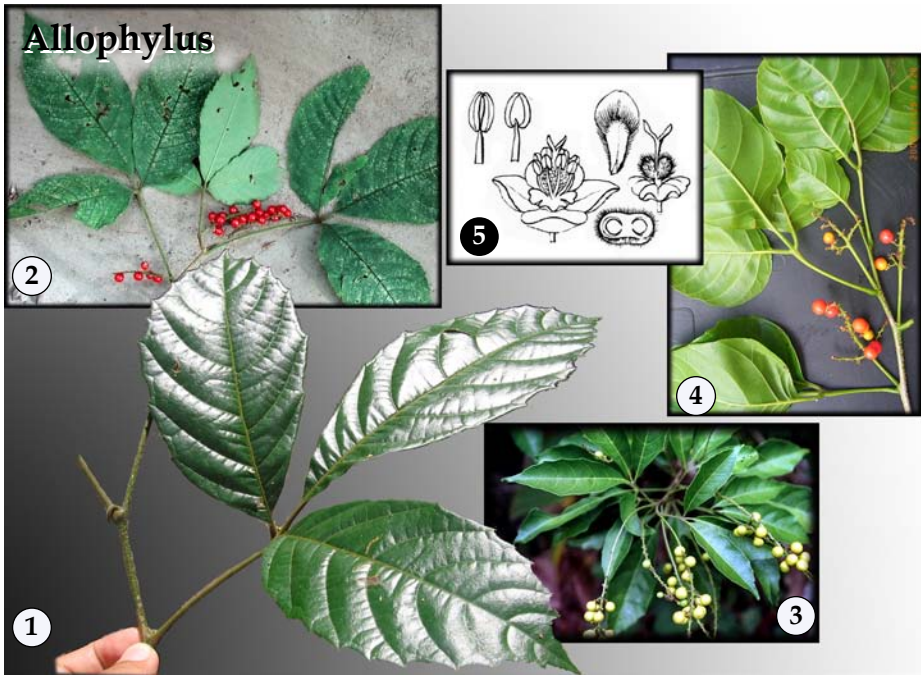


Trigonachras acuta, herbarium specimen from southern Malaya, stored at the Forest Research Institute of Malaysia; note the shape of the fruit.

SISYROLEPIS. [Greek, skin-like scale, reference to the petal.] Monotypic, *Sisyrolepis muricata*, widely in scattered locations throughout Mainland SE Asia. The



Tristiropsis acutangula, cultivated in the Bogor Botanic Gardens, Indonesia; note the very long twice-cut leaves; the pinnae are alternate, the leaflets alternate, one pinna enlarged.



Allophylus cobbe. The species is presented here in the very wide sense adopted by Flora Malesiana, but obviously includes a great diversity of biological species. 1, from Bataan, Luzon, Philippines, note the ragged toothed margin; 2, from central Thailand; 3, from Isabela, Luzon, Philippines; 4, from Palau Island, Philippines; 5, drawing of flower parts. (Photograph 1, © Ulysses Ferreras; 3, © Leonardo L. Co; 4, © Nestor Bartolome; 5, adapted from VIDAL *loc. cit.*)

leaves of about six pairs of opposite leaflets; the flowers violet in dense terminal inflorescence; the fruit a spiny angled and dehiscent capsule, the seeds orange-yellow arillate. (Not illustrated.)

TRISTIOPSIS. [Resembling *Tristira*.] A singular genus of three species, one Borneo endemic, *Tristiopsis ferruginea*; and *T. acutangula* in the Philippines, and east to Australia and Pacific Islands. Distinguished in the bipinnate leaves. The molecular study of Harrington failed to clearly resolve its position (based on *T. acutangula*). Monoecious trees, twigs lenticellate, short simple hairs, inflorescence axillary, flower regular, unisexual, the calyx in five unequal overlapping lobes, the corolla of five lobes, eight to 10 stamens, the ovary of three-four locules each with one ovule, the fruit, three-four angled, fleshy and indehiscent.

DICTYONEURA. [Greek, net-like nerves, reference to the leaf venation] Maybe five species, reduced to two or three for *Flora Malesiana*; a genus of the eastern parts of tropical Asia, from New Guinea to Philippines, once in Sabah. The most common species is *Dictyoneura acuminata*. Small trees, leaves with about seven pairs of leaflets, subopposite, the margin slightly toothed, sparsely hairy on the midrib and nerves, no domatia, inflores-

cence a few branched raceme axillary, flowers unisexual mixed in the inflorescence, sepals five, petals none, stamens five, ovary sessile, two celled, one ovule per cell, developing into a single lobed capsule about one-two cm long, that splits as it dries, the aril variably covering the seed (?).

A - *Allophylus* Group - a

ALLOPHYLUS. [Greek, for not related, in reference to the singular tri-foliolate leaf; note that it is not *phyllus* as for a leaf.] one to 200 closely-related and locally-differentiated species usually treated under a single name, *Allophylus cobbe*, found all around the Asian tropics. If the different forms are recognized, it is difficult to known to stop; for example, the Philippines claims 28 narrow species. These bear trifoliolate leaves (rarely one or five leaflets) with coarsely serrate margin. Axillary inflorescence with several long hanging, racemose axes; flowers unisexual, sepals four, petals four, stamens eight, ovary deeply two-lobed, one ovule per cell, usually only a single locule develops into a drupe about two-five mm across, usually ripening a bright red. Great ecological variation, but especially obvious along streams, seashores, and in fairly well-lit places rather than the forest understory.

ROSIDS (MALVIDS): SAPINDALES

SIMAROUBACEAE

NAME: From the genus of Neotropical trees, *Simarouba*. The common family name is sometimes Bitterwood, or follows form one of the better known species such as Tree of Heaven.

OVERVIEW: A decidedly minor family in richness and ecological significance with 22 genera and about 100 species, pantropical and subtropical in distribution, and a few species, such as *Ailanthus*, also abundant in the North Temperate Zone.

For the last ten or fifteen years, studies of phylogeny, molecular and otherwise, have been paring away genera from the family^{1,2,3}. *Harrisonia* is now in the Rutaceae; *Irvingia* is in its own family, *Allantospermum* is allied with Ixonanthaceae within the Malpighiales. Although *Picrasma* lies within a clade that is sister to the rest of the family and has been treated as a separate family, Picrasmeace⁴, I leave it here in a broader family.

The Simaroubaceae are woody plants that include fast-growing light-wooded trees, and a few slow-growing small trees of the forest understory. They are best known for the bitter constituents of the bark and wood and the numerous medicinal uses to which they are put. The leaves are in spiral clusters, the twigs with a wide pith.

¹Fernando, E. *et al.* 1995. American Journal of Botany 82: 92-103.

²Chase, M. *et al.* 1999. American Journal of Botany. 86: 1191-1199.

³Clayton, J. *et al.* 2007. International Journal of Plant Science 168:1325-1339.

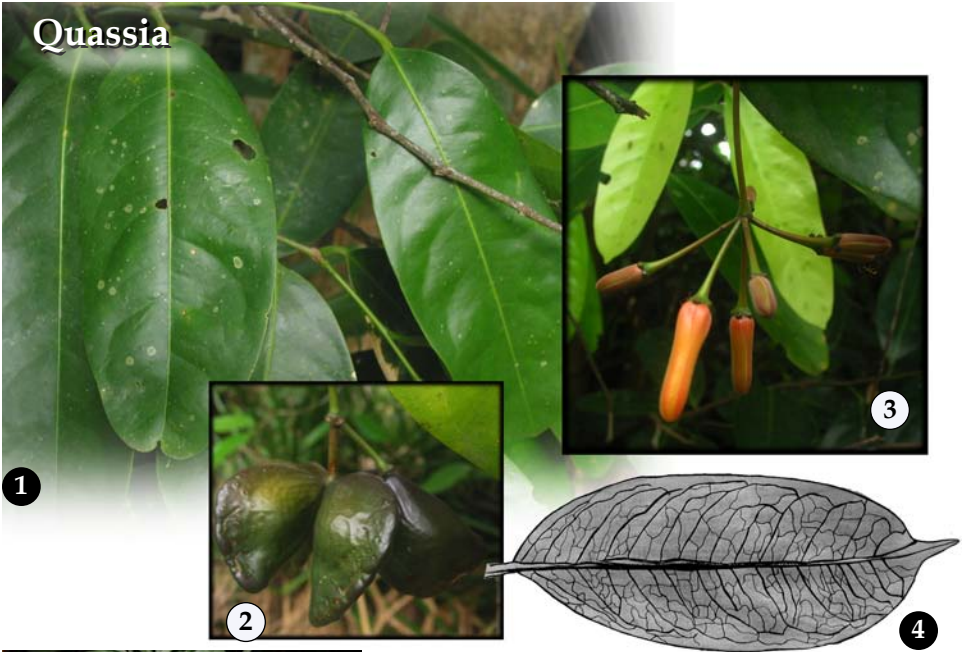
⁴Fernando, E. *et al.* 1995. Taxon 44: 177-181.

The leaves are compound, the leaflets opposite, typically with a short leaflet stalk. Worldwide there is some variation in the presence of a toothed margin and stipule like bodies at the leaf base, but in our species, the leaflet margins are entire.

EURYCOMA. [Greek, reference to the broad ring of hairs within the flower.] This small genus of three similar species is one of the best known medicinal plants of the lowland equatorial forests; *tongkat ali*, in Malay, the Iban *sengkanyat* is fairly widespread in Borneo. The most abundant species is *Eurycoma longifolia* which is abundant and widespread in the Sundaic Region, rarely reaching 10 cm DBH and 7-10 m tall. The leaves are often one m long, with numerous leaflets, uniform and sessile, the leaves in a crowded rosette at the end of the long branches. When young, it is a single-stemmed plant with something of the *schoepfsbaum* habit. These are dioecious trees, the flowers in large open dangling panicles. Practitioners of traditional medicinal almost always combine this with other plants, and in my experience, they tend to intentionally misinform investigators as to exactly what they are doing. Consequently, while *Eurycoma*, and most other Simaroubaceae, undoubtedly



Eurycoma. 1-4, *E. longifolia*, 1-2, Pasoh, Malaya note the long leaf, open sparsely flowered inflorescence; 3-4, from Lambir, Sarawak; 4, line tracing of single leaflet.



Quassia. 1-3, *Q. indica*, Palaui Island, Philippines; 4, tracing of a single leaflet, from Lambir; to the left is the Neotropical species *Q. amara*. (Photographs 1-3, © Leonardo L. Co.)



contain bioactive compounds, much of what has been written about them should be viewed with scepticism.

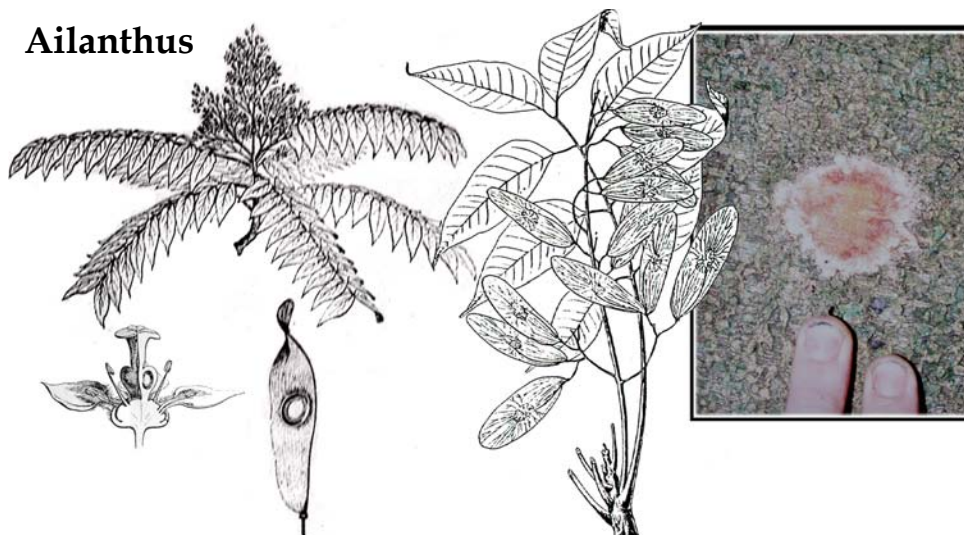
AILANTHUS. [From a Moluccan name in reference to the fast growth.] About five to 10 species, from India to Australia. Includes *Ailanthus altissima*, the Tree-of-Heaven, probably not native to tropical Asia and not much seen, but an aggressive invader of North America, Europe and Australia, combining fast growth, abundant wind-dis-

Brucea



Brucea. *B. mollis*, Palaui Island, Philippines, spirally arranged compound leaves and close-up of flower. (Photograph of habit, © Ulysses Ferreras; close-up of flower, © Daniel Lagunzad.)

Ailanthus



Ailanthus. 1-3, *A. glandulosa*, habit, detail of flower and winged fruit; 4, *A. malabarica*, habit and fruit; 5, bark and hard yellow-orange wood, *A. triphysa*, Thailand. (Illustrations 1-3, BAILLON, *loc. cit.*; 4, BRANDIS *loc. cit.*)

persed seeds and allelopathic roots. The widely known English name is very old and may derive from the fast growth but it is not clear. *Ailanthus triphysa* an important tree of dry open forests of mainland tropical Asia, often cultivated in reforestation and plantations from India eastward. *Ailanthus integrifolia* in Tagalog as *mala-sapsap*, sometimes in Malay as *mata gila* in reference to the leaf glands.

BRUCEA. [Commemorates J. Bruce, d. 1794, Scottish explorer.] A genus of six species, Africa and Asia.

Brucea javanica is found from Sri Lanka to Australia. It is a not infrequent small tree of secondary forests and margins. The leaflets are strictly opposite, soft and hairy with toothed margins. All parts of the plant are very bitter and it is a widely used traditional medicine especially for dysentery and gastric complaints. The Malay name is *ladah pabit*, and in Java is called *malur*. The Philippines also claims *Brucea mollis*.

QUASSIA. [Commemorates Quassi, a native of Surinam who informed local botanists about the medicinal properties of the tree.] Treated as 25 species with a world-wide tropical distribution, but the cited molecular evidence aims toward a division in which the Asian species will be renamed. About three species in tropical Asia. *Quassia indica* and a related species are common in coastal swamp forests. They bear simple leaves whereas *Q. borneensis*, endemic to Borneo, has two-four pairs of leaflets and a terminal leaflet. The Neotropical species, *Q. amara*, is cultivated around Asia.

Picrasma



Picrasma javanica, Huai Kha Khaeng, Thailand, leaf shape and detail of terminal bud.

PICRASMA. [Greek, to cause a bitter taste.] A genus of shrubs and small trees, less than 10 species, in tropical America and temperate Asia with one species, *Picrasma javanica*, widespread in seasonal parts of tropical Asia, from Mainland SE Asia to eastern Borneo. It is readily distinguished by the squat terminal bud.

SOULAMEA. [From a Ternatean name for the plant.] nine Pacific Islands, only *Soulamea amara* westward to Borneo; unrecorded from the Philippines but probably to be found on the east coasts. The simple leaves are spirally arranged in clusters at the ends of the stout branches. A not surprising element of the *Barringtonia indica* beach vegetation, but not very abundant. (Not illustrated.)

MELIACEAE

NAME: From the genus *Melia*, as below. In English as the Mahogany Family, after the true mahogany, *Swietenia* of the American tropics, and in Asia often named after the common fruit trees, Langsat and Santol Family.

OVERVIEW: The Meliaceae are a species-rich and uniformly abundant family in most of the tropical and subtropical world, equally at home in the everwet lowlands and the dry-seasonal lands. The most recent accounts of the family^{1,2,3} tally about 565 species and 51 genera. While most of the species are trees, large or small, and a few features are fairly widespread among taxa, the family shows all signs of rampant pleisiomorphy with most genera defined only by combinations of features, any one of which might also be found elsewhere. Studies of molecular data^{4,5,6,7} have demonstrated the monophyly of the two subfamilies, Cedreloideae and Melioideae, and clarified their limits while neither confirming nor rejecting the monophyly of the morphologically based tribes. The limited sampling (most genera were represented by a single species) precluded any recommendations on generic reorganization.

In general, these are medium to large trees with dense upturned feathery clusters of pinnately compound leaves. The body of the plant is resinous, in some species the leaflets bear translucent dot glands, the trunk sometimes with a white exudate. The inflorescence is an axillary thyse, short and few flowered or vast and dense. The most common flower type is bisexual with parts in fives, the calyx short and more or less fused, the petals white and spreading. The stamens form a narrow staminal column of the joined filaments, the anthers held at the apex while the large stigma emerges just beyond. That said, there is much variation in detail, some of which is described in the course of the survey of genera. Here we might emphasize the extent of diversity in the family by noting that the leaves can be thrice-compound (*Melia*), pinnately compound with a terminal leaflet and simply leaflet stalks (*Aglaiia*, etc.), or twice-swollen leaflet stalks (*Walsura* and *Heynea*) or reduced to tri-foliate (*Sandoricum*) or even unifoliate (*Aglaiia meliosmioides*), pinnate compound without a terminal leaflet (*Toona* etc.), or likewise but with an indeterminate leaf-tip (*Chisocheiton* and *Dysoxylum*, in the latter sometimes the leaves decussate-opposite), and, rarely, simple-leaved (*Vavaea*).

The two subfamilies are distinguished both by form and ecology. The main subfamily in tropical Asia is the Melioideae wherein the apical buds are said to be naked, at least they are not enclosed and protected by scale leaves, but they are often granular hairy. They are further distinguished by the relatively few ovules per carpel and the mature fruit as a more or less fleshy and indehiscent berry, but also as a less than fleshy dehiscent fruit with arillate seeds, and rarely as a dry nut; in all cases the seeds are without wings. While the sarcotesta may sometimes be called an aril, it is not from the funiculus.

The second subfamily is the Cedreloideae wherein the apical buds of the twigs are protected by clusters of sharp scale leaves, many ovules per carpel and the fruit is a dehiscent capsule with a persistent central columella bearing winged seeds.

In ecology, the *Melia* subfamily reaches its chief richness and abundance in wet equatorial lowlands, whereas the *Swietenia* subfamily is of greater abundance in the dry-seasonal lands, especially from India to Thailand, where they can become the most abundant forest representatives of the family. In the Sundaic Region, the few species of Cedreloideae tend to occupy forest gaps and degraded areas, sometimes becoming abundant in secondary forests.

Most species of Meliaceae bear flowers that are morphologically bisexual. However, there is some suspicion that many are functionally unisexual with either a monoecious or dioecious habit. The staminal column and precise arrangement of anthers and staminodes suggest specialized pollination, but there is little definite knowledge. Those species that bloom by day are visited chiefly by small bees, night blooming species by moths and perhaps beetles. Spider-hunters can be seen to probe the staminal tube of some species of *Chisocheiton*, but they may not necessarily be an effective pollinator.

The small winged seeds of the Cedreloideae are dispersed by wind, which would correspond with the open dry habitat. Of the Melioideae the most obvious features of the fruit are the large size of the seeds, the presence of a sarcotesta and the bright red, yellow and orange colors of the pericarp. Then there is also the prevalence of cauliflory especially in *Chisocheiton* and *Dysoxylum*, which contrasts with the fruit of *Aglaiia* and relatives which most often bear their fruit below or among the leaves. While these fruits are obviously an important part of vertebrate diet, there are few direct observations on the movement of the seeds, and relative role of mammals

FIELD RECOGNITION: MELIACEAE

Trees and shrubs highly varied in stature, most are at least mildly resinous, many with at least weak white exudate.

Leaf form is highly varied, mostly compound in feathery upturned whorls.

Individual genera are often readily recognized: *Melia* by thrice cut compound leaf; *Walsura* and *Heynea* by the evenly pinnate compound leaf with twice-swollen leaflet stalk; *Aglaiia* by the reddish scales on the lower leaf surface; *Chisocheiton* and *Dysoxylum* by the compound leaf with indeterminate tip.

¹Pennington, T. *et al.* 1975. *Blumea*. 22: 419–540.

²Mabberley, D. *et al.* 1995. *Flora Malesiana* 12: 1–407.

³Mabberley, D. *et al.* 2007. *Tree Flora of Sabah and Sarawak*. 6: 17–218.

⁴Muellner, A. *et al.* 2003. *American Journal of Botany*. 90: 471–480.

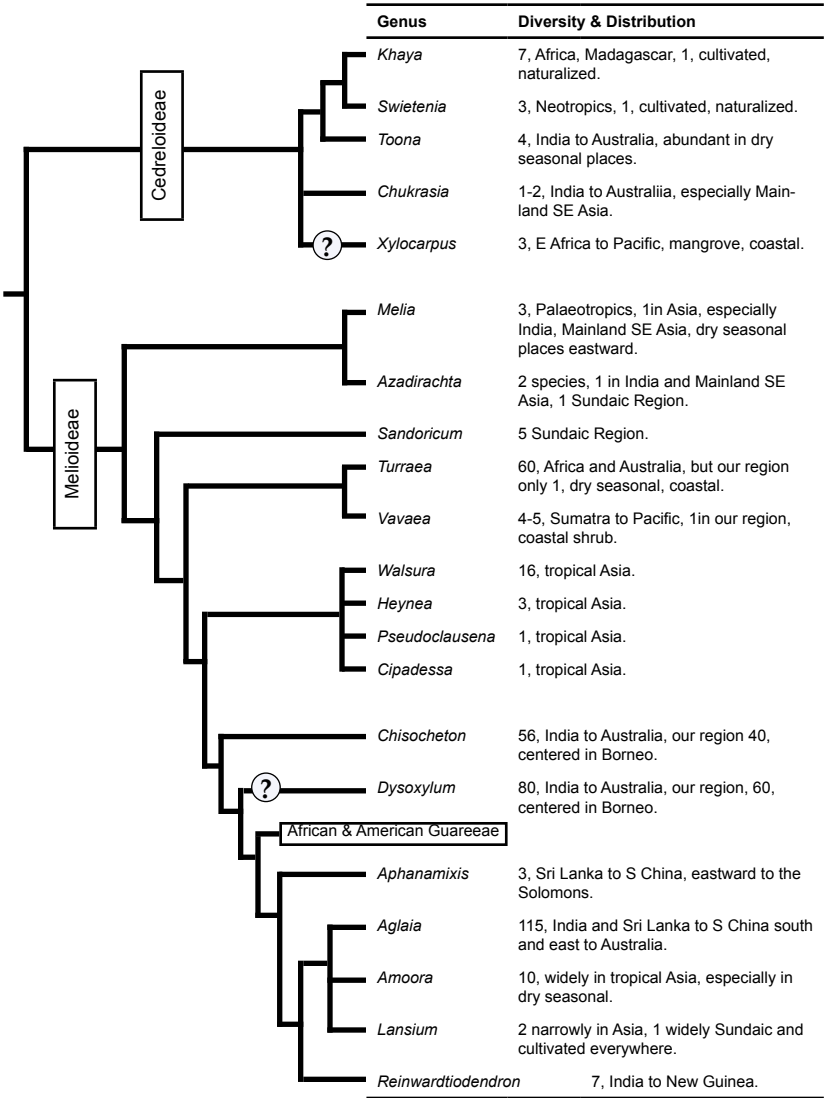
⁵Muellner, A., *et al.* 2005. *American Journal of Botany*. 92: 534–543.

⁶Muellner, A. *et al.* 2006. *Molecular Phylogenetics and Evolution*. 40: 236–250.

⁷Muellner, A. *et al.* 2008. *Taxon*. 57: 98–108.

Phylogeny of Meliaceae

The following phylogeny is restricted to the genera of trees in tropical Asia; the clustering following the articles cited in the family introduction. There are no pantropical genera in the Meliaceae. The Cedreloideae (formerly = Swietenioideae) is chiefly African and America with 14 genera, 2 genera native to Asia, and *Xylocarpus* still of uncertain placement. The Melioideae is represented by 36 genera. The tentative position of the American and African species related to *Chisocheton* is indicated.



and birds is unknown as is the potential of secondary dispersal by ground mammals.

With regard to richness and abundance, the Meliaceae often rank high in species numbers for surveys of lowland equatorial forests. In the 52-ha plot in Lambir Hills, we found 55 species; in the 50-ha plot at Pasoh, 45

species. However, the trees are usually only of moderate abundance, making up some 10% of trees over 10 cm DBH. In some circumstances, perhaps involving soils and disturbance, the family gains a greater dominance. For example, in the 16-ha plot in Palanan, in northern Philippines, we found 19 species with a collective abun-

dance just behind that of the Dipterocarpaceae. Other forests of this sort, which might be called Meliaceae forests, are found in Java and Borneo.

The view of the economic exploitation of the family is sometimes so dominated by the valuable timber of the American mahoganies that we can easily overlook the wide range of products in Asia. Our fruit trees, especially *Lansium* and *Sandoricum*, (and also a others only locally appreciated, such as *Aglaia korthalsii* in North Malaya) are among the most valuable fruit trees of the home orchard. The family is chemically rich and a common choice for the exploration of new products. In particular, the *neem* tree, renowned since ancient times for medicine, and still planted around homes as an effective mosquito repellent, continues to be studied for its many constituents.

☞ - *Swietenia* Subfamily - ☞

KHAYA. [From an African language, possibly for the tree, but *khaya* means 'home' in the Nguni group of languages.] The African mahogany, *Khaya senegalensis*, is grown for shade and timber, especially in Mainland SE Asia, south in Malaya, and especially around cities. It can reach an enormous diameter (see the photo of the tree in the Saigon Zoo). While it has the potential to be invasive (as in Australia), at present it does not seem to be naturalized in tropical Asia.



The African timber tree, *Khaya senegalensis*, here in the Saigon Zoo, about 100 years old and over 2 m in diameter. (Note the person walking behind the tree.)

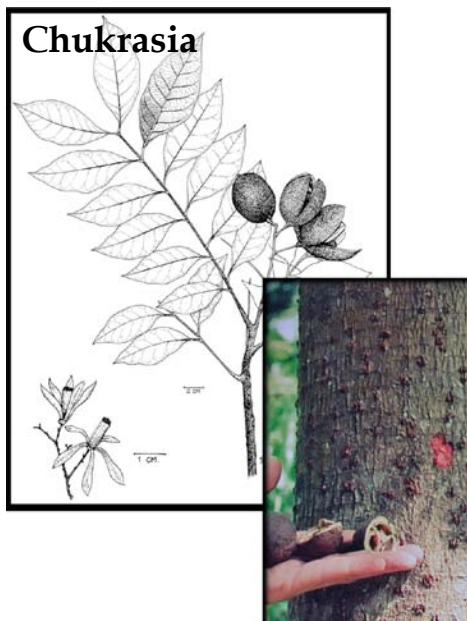
SWIETENIA. [Commemorates G. van Swieten, d. 1772, Dutch physician.] The genus includes two or three species of the Neotropics, and *Swietenia macrophylla* introduced throughout most of tropical world around the turn of the twentieth century. Planted in 1910 at the Forestry School in Los Banos, Luzon, Philippines, the grove of trees there are now very large and regenerate widely around the forest edges. Where it does not invade, the deciduous leaf fall nonetheless fills the adjacent forest floor with alien leaf litter, most of it evidently inedible to our native fauna. The tree has gained favor in the last four decades principally because it is easy to gather seeds, grows quickly, is resistant to most pests and eventually yields a timber that adequately replaces the native *red meranti* of the Dipterocarpaceae, at least for local uses.

It might be appropriate here to state what should be obvious: that 10 ha of *Swietenia* is not a forest. Certainly a tree cover of any sort provides some economic value and prevents the worse sort of soil erosion. But the biodiversity of such plantations is exceedingly poor. Vertebrates, insects and even the fungi and soil organisms find little use in these exotic woodlots.

TOONA. [From the Indian name for *Toona ciliata*.] Four or five species are distributed from India to Australia; the genus includes the well-known toon tree, or Australian red cedar, *Toona ciliata*, with a distribution equal to the genus. Considering the importance of *T. ciliata* in the Australian timber trade, it is surprising how little is



Swietenia macrophylla, 1, 100-year old tree, deciduous in May, dropping yellow leaves; 2, leaf, opposite or subopposite leaflets, aymetric blade, without a terminal leaflet; 3, apical bud of twig, with sharp bud scales.



Chukrasia tabularis, Huai Kha Khaeng, Thailand, line drawing adapted from BUNJAVECHEWIN *loc. cit.*

known about *Toona* within the equatorial parts of tropical Asia. The name *calantas* is used in the Philippines for what may or may not be the same thing. The small petalous flower with free stumpy stamens differs from the ordinary type we might associate with the Meliaceae, and distinguishes the genus from all others. The trunk itself, with dark scaly and fissured bark, looks much like

the forest form of *Chukrasia*, but is immediately distinguished by the sweet resinous odor.

CHUKRASIA. [From an Indian name.] The genus is usually treated as a single species, *Chukrasia tabularis*, the chickrassy or Chittagong trees, which is found naturally in India and Sri Lanka eastward to Thailand and Vietnam and with increasing dubiousness of its invasive status southward to northern Malaya and northern Sumatra. It has been found in Borneo near Bau and Serian Districts, but the antiquity of these populations is open to question; certainly *Chukrasia* is an aggressive invasive weed in Australia. Molecular studies of relatedness would be useful in mapping the spread and perhaps also in clarifying whether or not two separate entities can be found. A great many names have been published and the treatment in *Flora Malesiana* was sensible in reducing them to one. Nonetheless, field biologists and foresters in Thailand recognize two different kinds of trees. In mature forest this can be a large tree, exceeding 100 cm DBH and 40 m tall, the bole cylindrical, flared at the base with short rounded buttresses. The bark is dark brown and black, deeply furrowed, the inner bark red, and white, with no exudate and no odor. By way of contrast, in open dry deciduous forest we find the same species as a medium-sized tree usually less than 50 cm DBH and 30 m tall, often flowering at smaller sizes. The bole is cylindrical, gray more or less even with numerous large lenticels, sometimes cracked vertically. The leaflets tend to be velvety below. In both types the fruit is a five-part schizocarp, about three-four cm diameter, often found on the ground below older trees. If a species distinction is drawn, the smaller, velvet-leaved tree goes by *C. nimmonii* with much literature under the synonym *C. velutina*.

Toona



Toona ciliata, Huai Kha Khaeng, Thailand, line drawing on the left adapted from BUNJAVECHEWIN *loc. cit.*; floral and fruit details on the right from BRANDIS *loc. cit.*



XYLOCARPUS. [Greek, in reference to the woody fruit.] A genus of three species of tropical Asian coasts and mangroves, never of the inland forest. The two most common species are similar to one another in leaf form (opposite leaflets, two-three pairs) but otherwise individually distinctive: the large-fruited *Xylocarpus granatum* has a smooth light colored bark, the base without pneumatophores, and bears fruit that are up to 25 cm across. *Xylocarpus moluccensis* has a rough dark brown bark, the tree with dense pneumatophores, and bears fruit that are less than 10 cm across. The seeds are large, thick and corky, presumably floating in seawater. Their ecology is evidently distinct but further details would be useful, as would the relation to the third species, *X. rumphii*, a similar tree of rocky and sandy coasts.

MELIA. [Classical Greek name for the European ash.] Maybe three species, but especially *Melia azedarach*, sometimes in English as White Cedar, an important early successional tree of the dry-seasonal forests of India, Thailand and Indochina. *Melia* is large fast-growing tree with a cylindrical bole, bright brown bark with sharp deep fissures. The leaves are thrice cut compound. It has been widely cultivated in tropical Asia for a long time, and as with other cultivated Meliaceae the extent to which populations are native or naturalized or mixed is unclear. According to Leonardo L. Co, in the Philippines the native tree is called *bagalunga* and distinguished from the Indian-sourced cultivated trees which are called *paraíso*.

AZADIRACHTA. [From a Indian name for the *neem* tree.] Two species, one an Indian tree planted everywhere in tropical Asia and one native to the equatorial forests. The *neem* tree is *Azadirachta indica*. It has an origin perhaps in India and Myanmar, but is now known exclusively from cultivation. A great literature has developed around the chemical constituent azadirachtin and its potent biotic effects which are generally insecticidal among others. The living tree itself serves as an effective deterrent to mosquitoes and is grown for that purpose. The Malay name *ranggu* is widely applied in Malaya, Sumatra, Philippines to New Guinea and especially Borneo.

The second species, *A. excelsa*, is a large tree of particular importance in Borneo, and less commonly in Malaya and also Palawan, Philippines. In Borneo, it is of



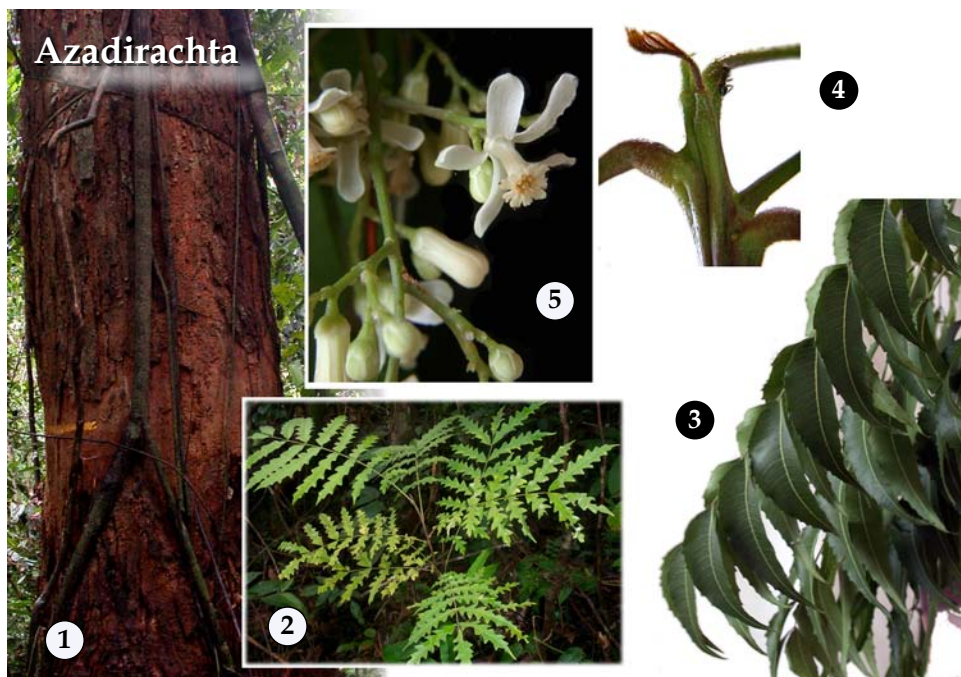
Xylocarpus granatum, leaves and flower, mangroves in the Philippines; drawing of large woody fruit. (Photographs © Leonardo L. Co; drawing adapted from BROWN *loc. cit.*)

scattered occurrence in lowland forests but usually as an indicator of rich soils. The leaf of the mature tree is pinnately compound without a terminal leaflet; the leaflets have an entire margin. However, the saplings in most

Melia



Melia azedarach, 1, drawing from BLANCO *loc. cit.*; 2, flowers with lilac staminal tube typical of the cultivated forms in the Philippines (take to be from an Indian source) and contrasting with the white of the native trees; 3, scaled lower surface of the leaflets.



Azadirachta. 1-2, *A. excelsa*; 1, trunk of a large forest tree, Sarawak; 2, sapling leaves, Philippines, sometimes twice compound, the leaflets with strongly serrate margin, adult leaves are once compound with few teeth; 3-5, *A. indica*, the neem tree, cultivated in the Philippines; 3, leaves, many uniform opposite leaflets, toothed margin, without terminal leaflet; 4, naked apical bud; 5, flower, in bud and open. (Photograph 2 © Leonardo L. Co.)

cases bear leaves that are deeply serrate or wavy toothed, and may even be twice cut compound.

SANDORICUM. [From the Moluccan name, *sandori*.] This is a uniform genus of five species, centered in Borneo. Molecular data (two species) indicates they are strongly monophyletic, isolated (usually treated as their own tribe) and sister to the combined *Turraea*-*Walsura*-*Chisocheton*-*Aglaia* groups. These medium sized trees are strictly and neatly tri-foliolate, the ultimate leaflet at the end of a short rachis. The flower is distinguished by a deep ribbing on the staminal tube. The best known species is *Sandoricum koetjape*, called *santul*, *santol*, or *kechep* or some variant. It is so widely planted, naturalized, re-selected and re-naturalized, that the natural distribution is probably lost to history. Whatever its origin, it is certainly found in most lowland forests at least within the Sundaic Region. The variety 'Bangkok' is a polyploid and bears fruit about double the normal size. Note that the edible portion is the mesocarp, not the aril which in fact is absent in *Sandoricum*.



Turraea sericea, longitudinal section of flower; adapted from BAILLON *loc. cit.*

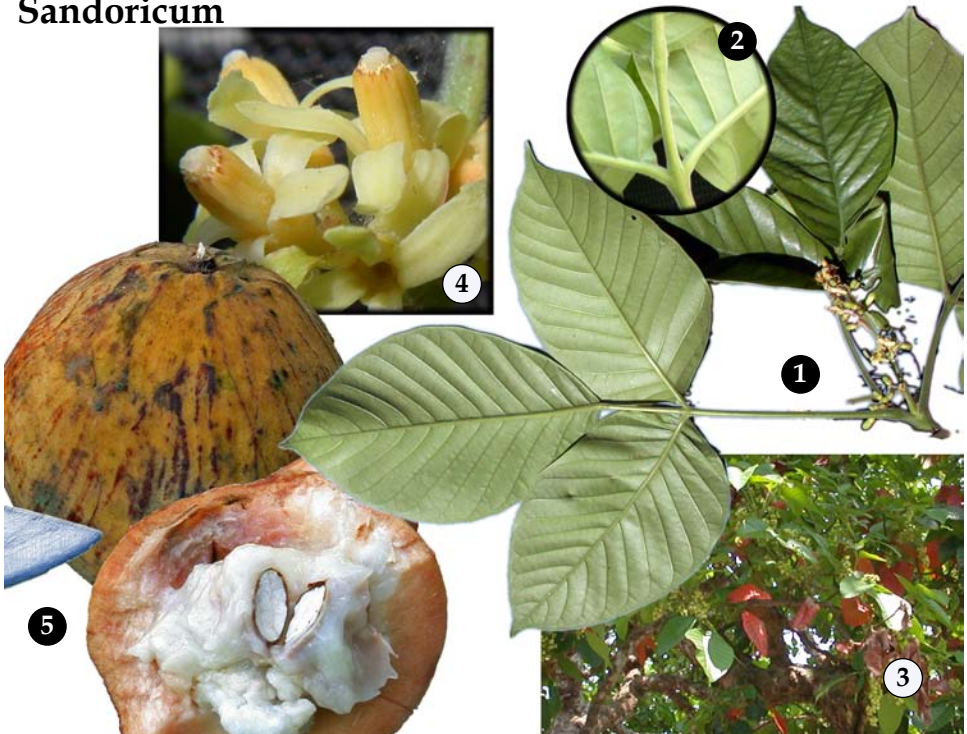
The genus also includes an abundant tree of peat swamps, *S. beccarianum*.

TURRAEA. [Possibly after the Italian botanist A. Turra, d. 1796.] About 60 species, of Africa and Australia with a single species in tropical Asia, *Turraea pubescens*, scattered in the strongly dry-seasonal and especially coastal habitats. It is recorded from China, Thailand, Indochina and E. Java, lesser Sunda Islands and north to the Philippines. A small tree or arching shrub. The leaf is essentially simple. Blooms when leafless, and then is very conspicuous.

VAVAEA. [From a Tonganese name.] Four or five species from Sumatra to Australia and Polynesia. Within our area *Vavaea amicorum* is an abundant small tree and multi-branched shrub on coasts, but also scattered in eastern forests and on exposed summits at 1000 m elevation. It is a widely variable species in details, and has a rich set of synonyms. It is particularly notable in the Pacific Islands south to Australia where it is an abundant fruit producer and can be a critical food source for many species of wildlife.

WALSURA. [From a Tamil name.] The genera *Walsura* and *Heynea* represent about 20 species of Asian trees that share a basic form with the large genus *Trichilia*

Sandoricum



Sandoricum koetjape. 1, twig with trifoliate leaf, flowers on short axillary axes; 2, the terminal leaflet on a short rachis; 3, leaves of the common cultivar turn red before withering; 4, the flowers with a staminal tube strongly ribbed; 5, the fruit, with knife tip showing the edible mesocarp.

which is currently regarded as restricted to Africa and tropical America. A segregated *Walsura* comprises 16 species from India and Sri Lanka to S China, south and east as far as New Guinea and north in the Philippines to Luzon. More than 50 names have been published under *Walsura*, but many of these are currently regarded as synonyms of *Walsura pinnata* which is consequently variable in many details and distributed across the entire range of the genus east of India. While it seems never especially abundant, it is one of the more consistent trees in the lowland equatorial forests. Many of the other species of *Walsura* are poorly described, and at least a few in Borneo are unnamed.

Walsura are peculiar and immediately recognized. They look as if they had the twice-swollen leaflet stalk of *Dacryodes* (Burseraceae) with the white, glaucous, papillose, leaflet of *Nephelium* (Sapindaceae). The 16 species of *Walsura* (with berries, except for *W. dehiscent*) and the three species of *Heynea* (with dry dehiscent capsules) are so similar to one another that the two most common species, *W. pinnata* and *H. trijuga*, can be easily confused to species, even in flower. (The illustrations in *Flora Malesiana*, or the floral photographs here, could easily be interchanged.) The most obvious field distinction is that *Heynea trijuga* bears domatia-like glands at the nerve axils of the lower leaf surface, *W. pinnata* does not.



Vavaea amnicorum, with simple leaves, Philippines (© Leonardo L. Co)

HEYNEA. [Commemorates B. Heyne, d. 1819, German missionary, superintendent of Bangalore Botanic Gardens.] Three species of tropical Asia. The most abundant species is *Heynea trijuga*, which has been widely described under the name *Trichilia connaroides*, from S China to Borneo and the Philippines. It is cultivated in Java, but evidently not naturalized. The fruit is a capsule about one cm long, splitting, the single seed with a thin translucent white aril, the seed dangling from the funicle. This is a common small fast-growing tree of secondary forests and roadsides in Borneo.

Cipadessa



Cipadessa baccifera, cultivated in Bogor Botanic Gardens.

spread and abundant in the forest understory. For a long time it was called *Walsura chrysogyne*, but looks nothing like other *Walsura*L. (Not illustrated.)

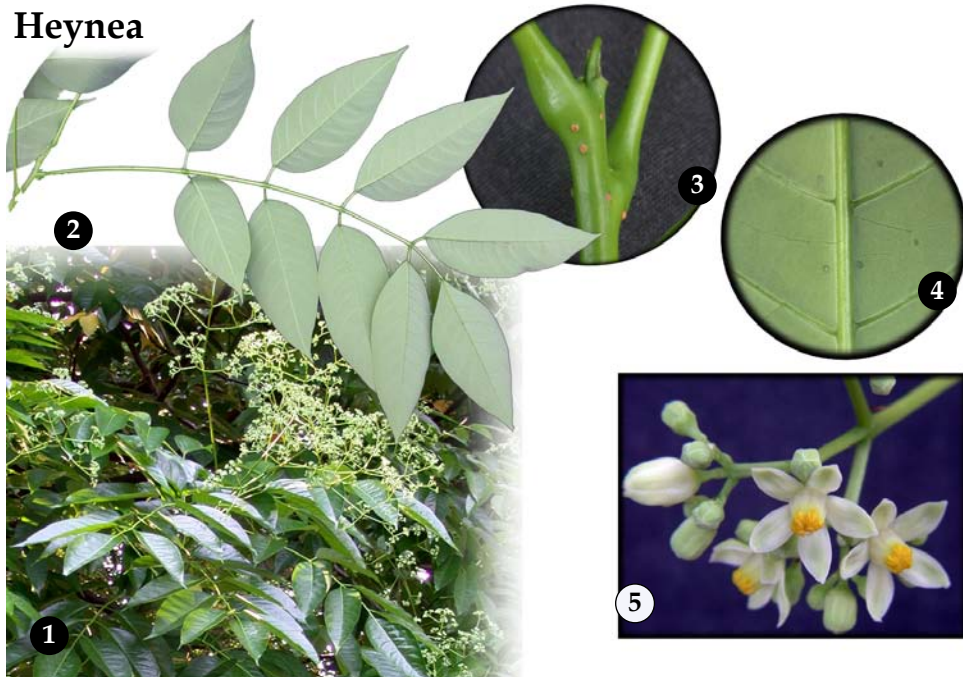
CIPADESSA. Monotypic, *Cipadessa baccifera*, a small tree or shrub, found widely in tropical Asia.

CHISOCHETON. [Greek for split tunic in reference to the divided staminal tube.] 53 species from India to S China, all of tropical Asia, as far east as Australia, with a center of richness in Borneo. The monograph in *Flora Malesiana* is a sound treatment, and yet there are still many species-level problems that require field study, such as the nature of the variable and widespread *Chisocheton patens*.

The tribe Guareaceae includes nine genera with an even pantropical distribution, represented by different genera in different continents. It appears to be paraphyletic with a monophyletic group of genera around *Aglaia* nested within. The two genera of tropical Asia, *Chisocheton* and *Dysoxylum*, share many features, including the peculiar growing tip of the compound leaf, a feature they also share in common with the Neotropical *Guarea*. Within Asia itself, *Chisocheton* is the more uniform of the two genera, and is distinguished by the ovule being orthotropic, whereas in *Dysoxylum* the ovule is anatropic. In so far as the latter ovule type is considered ancestral, and *Dysoxylum* is otherwise highly heterogeneous, it is pos-

PSEUDOCLOUSENA. [Greek, false-*Clausena*, a genus in the Rutaceae, where the species was first placed.] Monotypic, *Pseudoclausena chrysogyne*. A small tree distributed from Indochina to New Guinea, wide-

Heynea

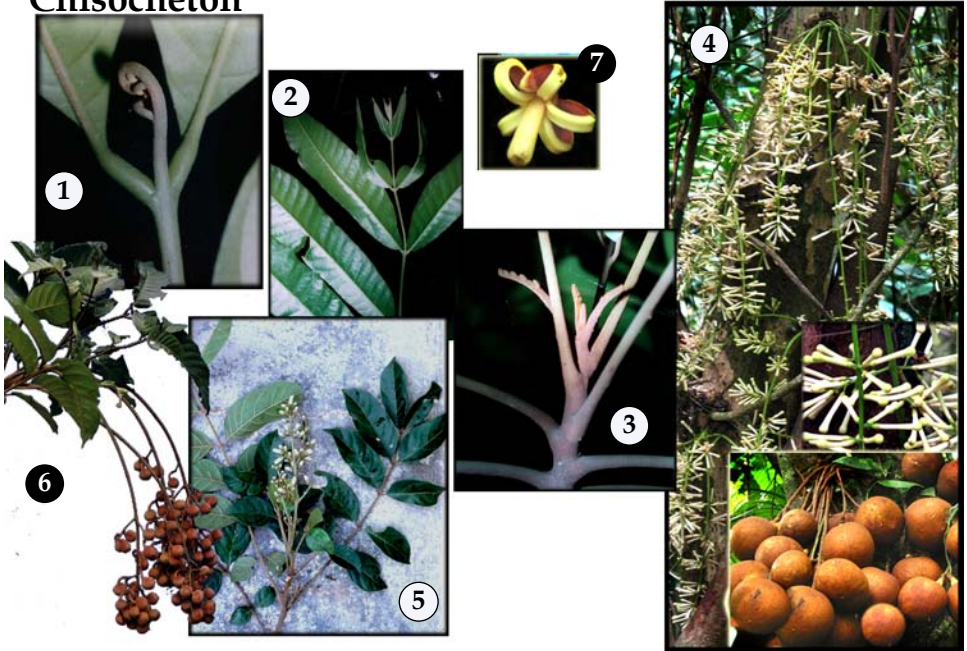


Heynea. 1-5, *H. trijuga*, cultivated, Los Banos, Luzon, Philippines. 1, small tree with axillary and terminal inflorescences; 2, pinnate compound with opposite leaflets, terminal leaflet, showing pale lower surface; 3, twig apex; 4, lower leaflet surface with axillary domatia; 5, flowers in bud and open.



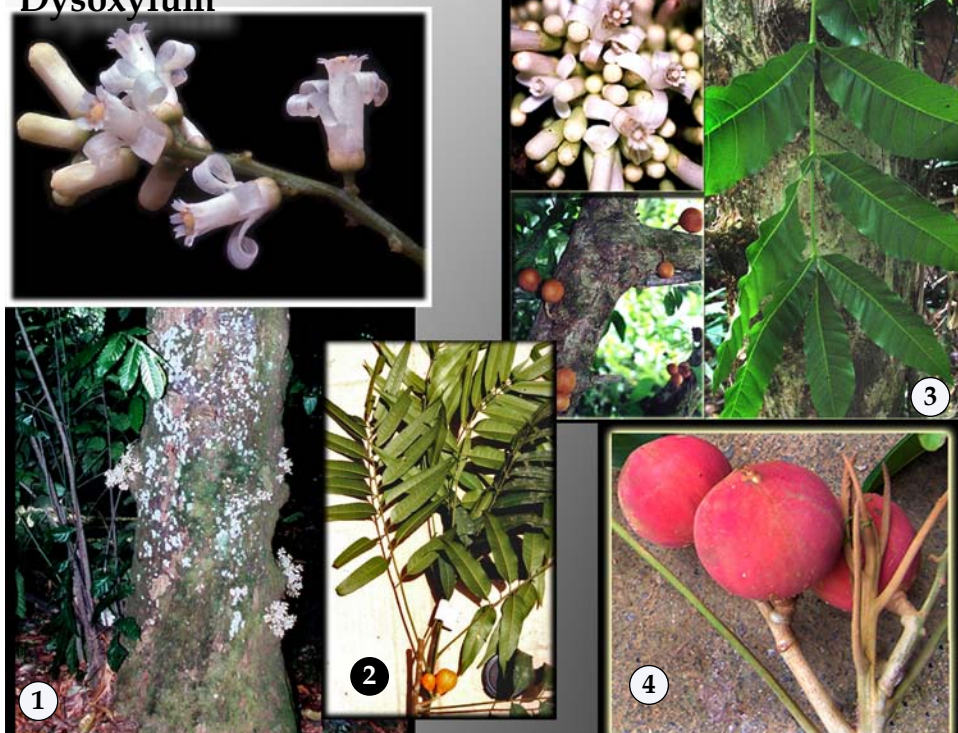
Walsura. 1-4, *W. pinnata*, Pasoh Forest, Malaya; 1, leaves with young inflorescence, leaf with 5 leaflets, one terminal, lower leaf surface pale and rambutan-like; 2, apical bud, naked and granular; 3, leaflet stalk is double-swollen, as in, e.g., *Dacryodes*; 4-6, *W. poilanei*, coastal forest in central Vietnam; 4, habit along a stream; 5, the 3-foliate leaves; 6 the flowers, in bud and open.

Chisocheton



Chisocheton. 1, compound leaf with opposite leaflets and a continually growing tip of new leaflets; 2, similar leaf tip with more mature leaflets; 3, twig apex; 4, composite photo of the densely cauliflorous *C. cumingiana*, Isabela, Luzon, Philippines, with insets of flowers and fruit; 5, floral specimen of *C. erythrocarpa*, Pasoh, Malaya; 6, fruiting specimen of *C. pentandrus*, Isabela, Luzon, Philippines; 7, flower of *C. ceramicus*, Isabela, Luzon, Philippines, unusual in red outside and yellow within. (Photographs 4, 6 & 7 © Leonardo L. Co.)

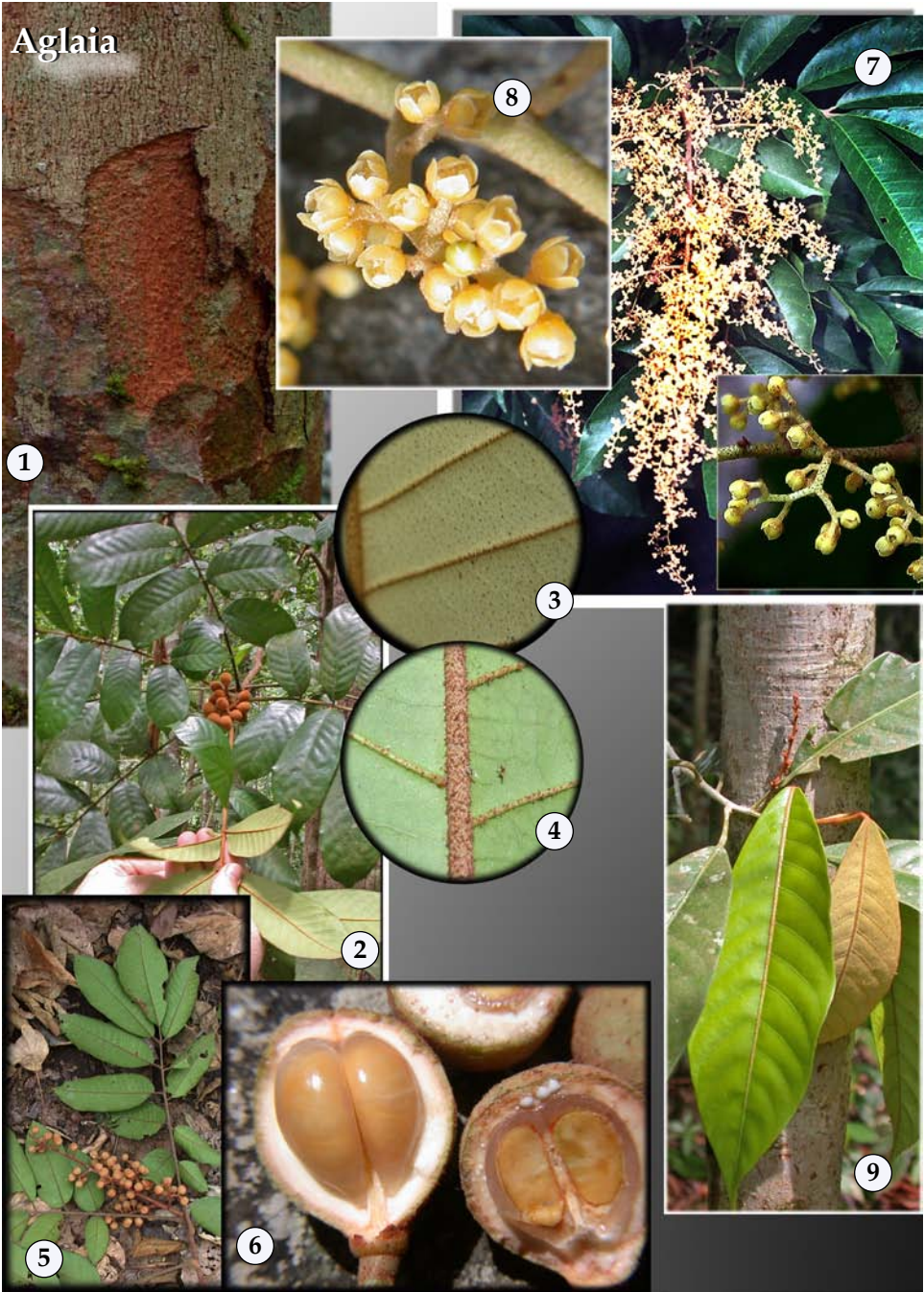
Dysoxylum



Dysoxylum. 1, *D. cauliflorum*, Bogor Botanic Garden, Java; 2, fruiting specimen of the distinctive *D. flavescens*, Lambir, Sarawak, with pear-shaped yellow-orange fruit and characteristic determinate leaves, with many leaflets, asymmetric base, drying green; 3, composite photo of *D. parasiticum*, Isabela, Luzon, Philippines, showing leaf with terminal leaflet, insets of flowers and fruit; 4, fruit of *D. oppositifolium*, with twig apex. (Photograph 4 & 5, © Leonardo L. Co.)



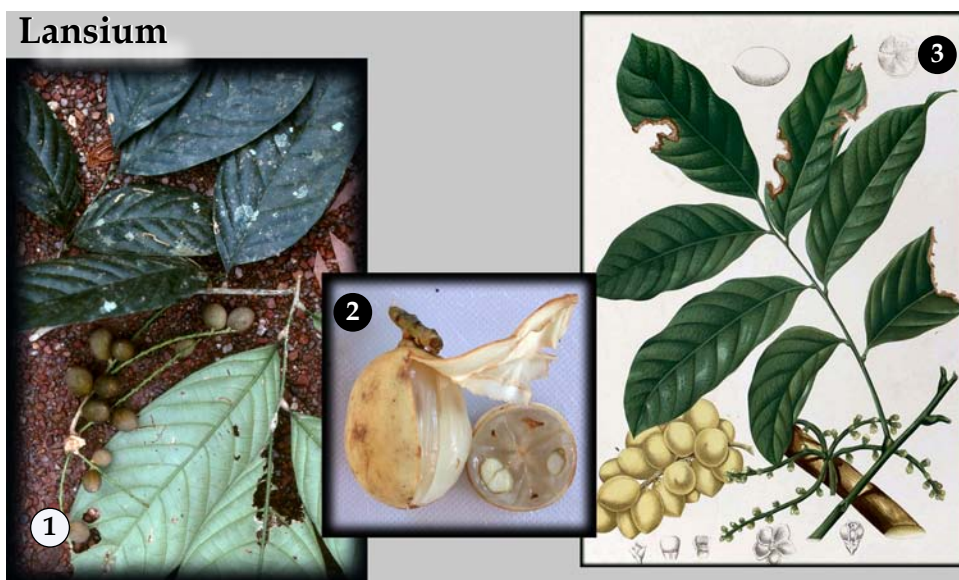
Aphanamixis. The exceedingly long infructescence with the fruit clustered at the tip is characteristic of the genus; 1, although called *A. polystachya*, this tree with the relatively long leaf stalks and looped nerves follows the description of *A. borneensis*, but the location in Palanan, Isabela, Philippines, is far north of its known distribution; 2, *A. sumatrana*, similar to *A. borneensis* but a small tree rarely more than 5 m tall, at Pasoh Forest, Malaya; 3-4, one of the many forms of *A. polystachya*, here densely and softly hairy, with fruit that I believe remain yellow in color, Lambir Hills, Sarawak, Borneo. (Photograph 1 © Leonardo L. Co.)



Aglaia. These photos illustrate the characteristic features of the genus, but individual species cannot be reliably identified from photographs, so the names are not given. 1, typical bark of larger trees, red, patchy, with scant white exudate; 2, pinnately compound leaf with terminal leaflet and strictly opposite lateral leaflets, clustered small orangish fruit in loose axillary infructescence; 3-4, reddish scaly stellate indumentum on lower leaf surface, notice the weak fine venation; 5-6, fruit, much like *Lansium*, with indehiscent fleshy wall, sticky white exudate, and thin translucent sarcotesta; 7, some species have larger and densely flowered inflorescences; 8, the flowers are relatively small for the family; 9, atypical of the genus is *A. meliosmoides*, Pasoh Forest, Malaya, with a leaf of a single leaflet. (Photograph 7 © Leonardo L. Co.)



Ammora. Left, *A. cucullata*, a species best known in India; center and right, *A. spectabilis*, Huai Kha Khaeng, Thailand; the leaf sample stapled to tree, the leaf with strictly opposite leaflets and a terminal leaflet, the red and white patchy bark is typical as is copious white exudate, the fruit (lens cap for scale) is only weakly dehiscent but it is easily broken apart by gibbons and other vertebrates to get at the large white arillate seeds.



Lansium domesticum. 1, Wild tree with fruit borne on larger branches, Pasoh Forest, Malaya; 2, cultivated fruit, Philippines, 3 cm long, thin, pliable outer peel and juicy sarcotesta within, typically with a few seeds; 3, drawing from BLANCO *loc. cit.*

sible, perhaps probable, that *Chisocheton* is nested somewhere within the broader genus.

In both genera, the flower are unisexual in either form or function. The fruit are dehiscent. These trees are not much used by people in the region. The name *buah pesa kanan* has become the standard in forestry departments and is applied to both *Chisocheton* and *Dysoxylum*.

DYSOXYLUM. [Greek for foul wood, reference to the fetid odor of some species.] 80 species, from India and Sri Lanka to Australia, species-rich in Borneo and Malaya where it represented by widespread species, and even more species-rich in New Guinea where it represented by endemic species. (The monotypic *Anthocarapa* - east of Borneo, except for an odd collection from Mt. Arayat, Luzon- is easily accommodated here, but needs a name under *Dysoxylum*). This genus is exceedingly heterogeneous in leaf form: in a few, the compound leaf tip continues to grow as in *Chisocheton*, whereas most species are compound with subopposite leaflets, and a few with a terminal leaflet. The leaf arrangement also varies from strictly opposite, decussate to spiral. Perhaps more than in *Chisocheton*, here we find many species that are cauliflorous. Two species might be mentioned. *Dysoxylum alliaceum* is widespread and commonly encountered, and notable for the powerful garlic scent of leaf and twig. *Dysoxylum caroliniae* is notable because it was formally described only in 1994, and yet it is a very large tree, among the largest in the family, and while of low abundance, seems to be commonly encountered. At least it was found in both the Pasoh 50-ha plot (at 60 cm DBH) and in the Lambir 52-ha plot (105 cm DBH). The leaflets are sub-opposite, the nerves very close, nearly dryobalanoid, with tufts of hairs as domatia in the nerve axils, while the leaves are opposite decussate from a thick and fleshy stalk.

APHANAMIXIS. [Greek from invisible mating, reference to the small stamens and hidden style.] Evidently a clade of three species. *Aphanamixis polystachya* is widespread and abundant from Sri Lanka and India to S China and tropical Asia eastward to the Solomons Islands. Two species are of narrow distribution: *A. borneensis* from Borneo and S Philippines and *A. sumatrana* from Malaya and Sumatra. Although small trees, they have exceedingly long pendent floral stalks. Little is recorded regarding their reproductive ecology.

AGLAIA. [From Greek mythology, Aglaia - the beautiful - was the youngest of the three Graces.] 115 species

from Sri Lanka and India to S China, Vietnam throughout tropical Asia to Australia, more than 60 species in Borneo. The standard Malay name is *segara*.

Aglaia in the broad sense is now considered paraphyletic, but nearly complete sampling will be needed to divide the genus into monophyletic groups. In all of these species the leaflets are opposite with a terminal leaflet. *Lansium* and *Reinwardtiidendron* are sister taxa, and modest evidence was found indicating that they are most closely related to *Ammora*.

In general, *Aglaia* are quickly recognized by the copper or golden scaly hairs on the twigs and lower leaf surface. The flowers are tiny for the family and usually arranged in spike or panicles, large or small by species. They are often fragrant. The fruits are indehiscent berries with a fleshy aril. A white exudate is common in the fruit and sometimes in the trunk.

AMMORA. [From a Bengali name for *Amoora cucullata*.] This is now taken to be a clade within the broad *Aglaia* group, distinguished chiefly by the large stature and dehiscent fruit. The number of species is not certain - more than 80 names have been published under the genus - but it is likely to tally fewer than 10. These are particularly common in dry seasonal forests of India and Mainland SE Asia, although a few species are found everywhere in tropical Asia. They include some of the most beautiful examples of the *Aglaia* group, large trees with great feathery crowns of dark green foliage.

LANSIUM. [From the Malay name *langsat*.] A genus of three species; two are narrowly distributed in Sumatra and Nusa Tenggara and the third is the native forest species, *Lansium domesticum*, now cultivated everywhere in the tropical world for the fruit. Forest trees have small sour fruit full of white exudate. The cultivars are mostly races of apomictic clones - wonderfully variable - some sweet as candy without a trace of acid, others more sour. Typically one or two segments have a mature seed which is extremely bitter. Some varieties are called *duku* or *duku langsat*. Similar to *Aglaia* but differs by the simple hairs, rather than stellate and by the five-locular ovary.

REINWARDTIODENDRON. [Commemorates CG Reinwardt, d. 1854, Director of the Bogor Botanic Gardens.] About seven closely related species, from India to New Guinea. (Not illustrated.)

ROSIDS (MALVIDS): SAPINDALES

RUTACEAE

NAME: From the genus *Ruta*, the European Rue, from a classical name.

OVERVIEW: The Rutaceae are chiefly small trees and shrubs of dry-seasonal climates in the tropics and subtropics, a few herbs, some climbers, sometimes with thorns. The leaves highly varied in form: pinnately compound, three-foliate, either type commonly reduced to a single leaflet, or in *Citrus* with a flattened leaf stalk that creates an interrupted blade. Commonly the blade is with pellucid dot glands and are strongly aromatic, often pleasantly so, sometimes fetid. The flowers are small, often green, pale yellow, or especially among the *Citrus* relatives, elegantly white and famously fragrant. They bear parts in fours or fives, stamens variable in number but often twice the petal number, the ovary superior with four-five locules each with two to many ovules. A glandular ring about the base of the ovary is characteristic if not diagnostic, as are hairs inside the carpel walls.

The cultivated orange reigns as the Queen of Fruits; unlike the apple, banana, mangosteen, peach or durian, no confectionery concoction improves upon it. While the orange may well be the most perfect of all foods, and presents a most welcoming invitation to the family Rutaceae, once inside the door a novice is apt to find a taxonomic and nomenclatural nightmare. Individual species, even those rare and geographically isolated, are typically clear enough. The problem lies in how to associate the species in meaningful genera, and to associate genera in larger groups. The Rutaceae includes less than 2000 species - perhaps less than 1500 - and yet we find over 400 published generic names; these are currently reduced to about 150 recognized genera with nearly half of these each representing only one or two species.

Molecular data, while not yet yielding a complete system, has made progress¹⁻⁶. *Harrisonia* and a few other non-Asian genera are relatively well-supported as a clade (recommended as subfamily Spathelioideae) that appears sister to the core Rutaceae, with their exact relationship requiring better information on the presence and development of the oil gland cavities that characterize the remainder of the family. One well-defined clade surrounds *Citrus* and relatives, and corresponds to the old subfamily Aurantoideae, characterized in general by a indehiscent berry. The other 120 or so genera show a variety of mostly geographically based clusterings, in-

congruent with former subfamilies and tribal systems. In recent years they have been informally lumped in a presumed non-monophyletic subfamily Rutoideae. These are characterized by a deeply lobed capsular fruit that dehisce to reveal the black shiny seeds. The vegetative form of this group is varied, with leaves that are pinnately compound and spiral or three-foliate and opposite, and with each type sometimes reduced to a single leaflet. One must note here the potential for further nomenclatural confusion caused by the finding by Gruppo *et al.*, that *Ruta*, the type genus of the Rutoideae, appears sister to the *Citrus* subfamily. The Rutoideae must always be the subfamily that includes *Ruta*. However, it now seems possible that within the span of a few years, the common meaning of Rutoideae will go from *Ruta* plus the 120 genera not in Aurantoideae to *Ruta* plus all genera that are in Aurantoideae.

Worldwide centers of importance for Rutaceae are S Africa with 26 genera and 302 species, and also Australia with 40 genera and 320 species. Tropical Asia is a third center of diversity but of relatively minor ecological significance. The numbers alone can be deceptive: China claims 22 genera and 126 species, while Sabah and Sarawak list 23 genera and 75 species of which 43 species are trees and shrubs. Malaya is similar with a family tally of 18 genera and 54 species; Philippines with 23 genera and 78 species.

From a regional perspective, we should first emphasize the strong skewing to monotypes. For example, in the cited Borneo study⁶, of 43 species of trees, 21 are in two genera, *Melicope* and *Glycosmis*, while the remaining 22 species are in 15 genera. Second, with regard to abundance, the Rutaceae are rarely a conspicuous part of the flora and that is especially true of the lowland equatorial forest. The plot inventories yield useful tallies: In Lambir, Sarawak, over 52-ha of forest, we found only three genera and five species representing about 12 trees per ha; in 50 ha of forest at Pasoh, Malaya we found four

FIELD RECOGNITION: RUTACEAE

Small trees with hard pale wood, and thin bark; without exudate, often odoriferous.

In leaf form, be prepared for highly varied form - pinnately compound and spiral, or 3-foliate and opposite. - and especially the reduction to a single leaflet - look for the twice-swollen leaf stalk and note the point of abscission.

The blade is oily, shiny, the color often yellow-green, with bright pellucid dot glands and evinces a strong odor, sweet, fragrant and citrus-like, or fetid.

Thorns are common among the trees of dry seasonal places.

The leaf stalk is sometimes winged, sometimes pulvinate.

Often with flowers and fruits; the fragrant flowers white, stamens with thick filaments, a conspicuous disc and broad knobby stigma; the fruits either fleshy berries with soft seeds or dehiscent capsules with shiny black seeds, in both the pericarp often bulky and glandular.

FIELD CONFUSION

Pinnately compound leaves might be confused with Sapindaceae or Meliaceae.

The pellucid dots glands can be found in several unrelated genera such as *Ardisia* (Myrsinaceae) and *Gonystylus* (Thymelaeaceae).

¹Chase, M. *et al.* 1999. American Journal of Botany. 86: 1191-1199.

²Scott, K., *et al.* 2000. Journal Plant Systematics and Evolution. 223: 15-27.

³Morton, C. *et al.* 2003. American Journal of Botany. 90: 1463-1469.

⁴Gropp, M., *et al.* 2008. American Journal of Botany. 95: 985-1005.

⁵Bayer, R. *et al.* 2009. American Journal of Botany. 96: 668-685.

⁶Jones, D. 1995. Tree Flora of Sabah and Sarawak. 1: 351-420.

⁷Auld, T. 2001. Cunninghamia. 7: 213-239.

genera and six species representing about 22 small trees per ha. The forest flora chiefly comprises *Glycosmis* in the shaded understory joined by a very few larger trees such as *Maclurodendron porteri*, the only forest species to exceed 10 cm DBH; *Micromelum* in large gaps and along roadsides by small trees of *Melicope*. We might then ask where are the many other Rutaceae of tropical Asia? The answer is they are scattered and patchy with sparse abundance on nutrient poor soils, riversides, beaches, mangroves, ultrabasics, high mountain outcroppings, and a few on limestones.

Tony Auld, in describing the 71 taxa around Sydney Australia, rightly describes the family ecologically neglected⁷. In that part of Australia, they can be particularly important on nutrient poor sandstone soils as part of heath vegetation, many abundant and conspicuous by virtue of floral display in spring. While far less conspicuous in Asia, their ecology also needs more attention if only to give a better view of the origin and diversity of the crop plants, for although the Rutaceae are of minor ecological importance in our region, they are among the most important of all plants with regard to the human economy. Products includes medicines, both new and traditional, a few resins, fragrances and spices. *Citrus* is the most significant of all fruit tree crops with annual global production of fruit and juice over 100 billion kg. Most commercial production of *Citrus* is based in Brazil, China and the United States. Production in tropical Asia, despite our rich native diversity, is of minor volume, the majority of fruit are consumed locally, most notable perhaps are pomelos and kalimansi.

Skimmia



Skimmia japonica, Cordillera, Luzon, Philippines. (© Leonardo L. Co.)

☞ - *Harrisonia* Group - ☞
Subfamily Spathelioideae

HARRISONIA. [Commemorates Charles Harrison, author *A Treatise on the Culture and Management of Fruit Trees*, 1825.] Four species of tropical Africa; two in tropical Asia, one of which, *Harrisonia perforata*, is

widely found in dry seasonal places from Mainland SE Asia, Sabah, Philippines and east to Australia. A thorny small tree, the Malay name is *kukalang*. The Philippines also claims *H. brownii*, at least in Palawan. The genus was long placed with doubt in the Simaroubaceae; the position here as sister to the remaining Rutaceae appears to be strong.

☞ - Former Rutoideae - ☞

SKIMMIA. [From a Japanese name.] Four species of warm temperate parts of Asia, with a single species, *Skimmia japonica*, southward at least to the Philippines. The leaves are simple, lanceolate, glossy green.

ZANTHOXYLUM. [Greek, yellow wood.] A widespread genus with more than 200 species, worldwide in warm places. In trop-

Harrisonia



Harrisonia perforata, Philippines, young stem with spines, pinnately compound leaf, and thorns on older tree. (Photograph in upper right, © Leonardo L. Co.)

Zanthoxylum



Zanthoxylum. 1, *Z. myriacanthum*, thorny stem and compound leaf, Migan, Philippines; 2-3, *Z. limonella*, Huai Kha Khaeng, Thailand, 43 cm DBH tree with wedge-shaped trunk spines; 4, *Z. integrifolium*, leaf and fruit, Palaui Philippines; 5, *Z. avicennae*, fruit, Mt. Mantalingahan, Philippines. (Photograph 1, © Ulysses Ferreras; 4 & 5 © Norby Bautista.)

ical Asia, these are found everywhere as prickly shrubs, scrambling climbers. In seasonally dry forests, *Zanthoxylum* can grow as larger trees. We find about 10 species in Mainland SE Asia, and eight in the Philippines, four in Malaya, and four on Kinabalu. Several species in China are the source of Szechuan pepper.

LUNASIA. [From a Tagalog name.] Monotypic, *Lunasia amara*, distributed from Java and Borneo to the Philippines and eastward to Queensland; not in Malaya nor in Mainland SE Asia. A not uncommon small tree of forest margins; odd in what appears to be simple leaves covered in reddish-gray scales and stellate hairs, and in the peculiar scruffy fruit.

MACLURODENDRON.

[Commemorates FA McClure, d. 1970, explorer and plant collector.] Six species found very widely from Thailand and Vietnam east to Borneo and Philippines, especially *Macclurodendron porteri* (formerly widely known as *Acronychia porteri*). This is widespread and fairly consistent element of the lowland forests, never abundant. The leaves are opposite and reduced to a single leaflet, usually obvious from the kneed leaf stalk. The blades have a pleasant odor and dot glands.

ACRONYCHIA. [Greek, clawed-petal] 42 species, principally Australian and New Guinea with a few species reaching west as far as India. The more common trees of our region formerly named here, such as the former *Acronychia porteri*, have been transferred to

Lunasia



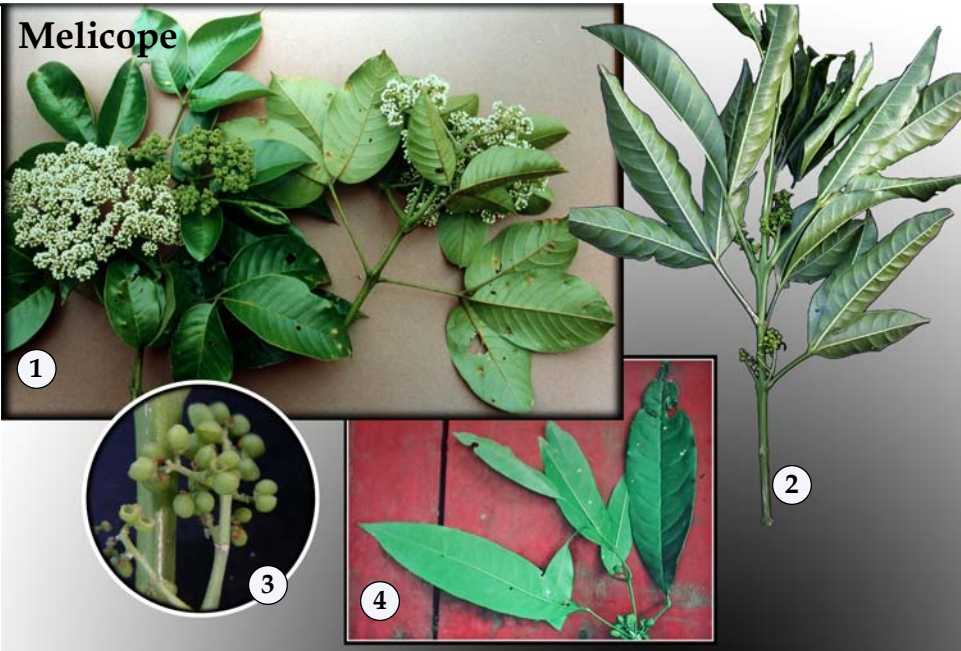
Lunasia amara, left and right, stem and leaves, from Bogor Botanic Gardens; center, fruit, Philippines. (Photograph of fruit, © Leonardo L. Co.)



Maclurodendron porteri, a mature tree of 21 cm DBH, Pasoh, Malaya, the 1-foliolate compound leaf, opposite arrangement, drawn from herbarium sample.



Acronychia, an unidentified and possibly new species, from high on exposed cliffs of Mt. Hamiaguitan, Philippines; note the twice swollen leaf stalk. (© Leonardo L. Co.)



Melicope. Most species with strictly opposite 3-foliolate compound leaves; 1, *M. accedens*, Lambir, Sarawak, with dense terminal inflorescence; 2-3, *M. triphylla*, Philippines, with small axillary inflorescence; 3, the small immature fruits are crisp and eventually split open; 4, *M. lunu-ankenda*, Huai Kha Khaeng, Thailand, with compound leaves reduced to a single leaflet.

Maclurodendron. The most widespread of those remaining are the small forest shrub *A. peduncularis*; otherwise the genus includes many narrowly restricted and poorly known species of New Guinea and the eastern Islands including Philippines. Most all bear opposite leaves with one or sometimes three leaflets and a twice swollen leaf stalk.

MEROPE. [From Greek mythology, of uncertain application.] Now usually regarded as a monotypic genus comprising the widespread mangrove, *Merope angulata*. Although not an abundant mangrove, it is often known by local names to people who live near its habitat. The Malay is *limau lelang*. (Not illustrated.)

MELICOPE. [Greek honey from a cut, reference to nectar from dissected disc.] A genus of about 150 species distributed from Madagascar to India, south China to Australia and the Pacific. These are abundant small trees and shrubs, especially in full sun along roadsides, sometimes in forest gaps. For most of the last century they were known as *Euodia* or *Evodia*. That genus has now been restricted to about six species of trees from New Guinea to Australia and the Pacific. Most of the species of our region formerly in *Euodia* have opposite three-foliate or reduced one-foliate leaves and are placed here in *Melicope*⁹. A few species with pinnately compound leaves are now in *Tetradium*. But *et al.* describe molecular data that supports the separation *Melicope* and *Euodia*¹⁰. Be careful not to confuse *Melicope* with *Vitex* and other opposite three-foliate leaved trees of the Lamiaceae; *Melicope* lacks the scar across the flattened node and the odor of the leaves is entirely different. The flowers of the inflorescence are sometimes dense, sometimes sparse; the fruit are small dehiscent capsules.

TETRADIUM. [Greek, for the four-part ovary.] About nine species, Himalayas to Japan and south in dry seasonal parts of Mainland SE Asia, Sumatra and Java. three species in our region. *Tetradium fraxinifolium* with opposite pinnately compound leaves, not infrequent in Mainland SE Asia. The former *Euodia meliaefolia* is a common forest gap and roadside tree in Mainland SE Asia, with long leaves bearing seven or nine leaflets - illustrated in THROWER *loc. cit.*

TETRACTOMIA. [Greek, the carpels split in four.] Six species, chiefly New Guinea. Small trees with opposite one-foliate leaves, the flowers bisexual, parts in fours, the ovary of four carpels joined by a single style. Maybe only *Tetractomia tetrandra* scattered widely in our region, not uncommon in disturbed places over poor soils.



Clausena excavata, drawing adapted from BUNYAVECHEWIN *loc. cit.*

☞ - *Citrus* subfamily - ☞
Former Aurantioideae

A - *Clausena* Group - a

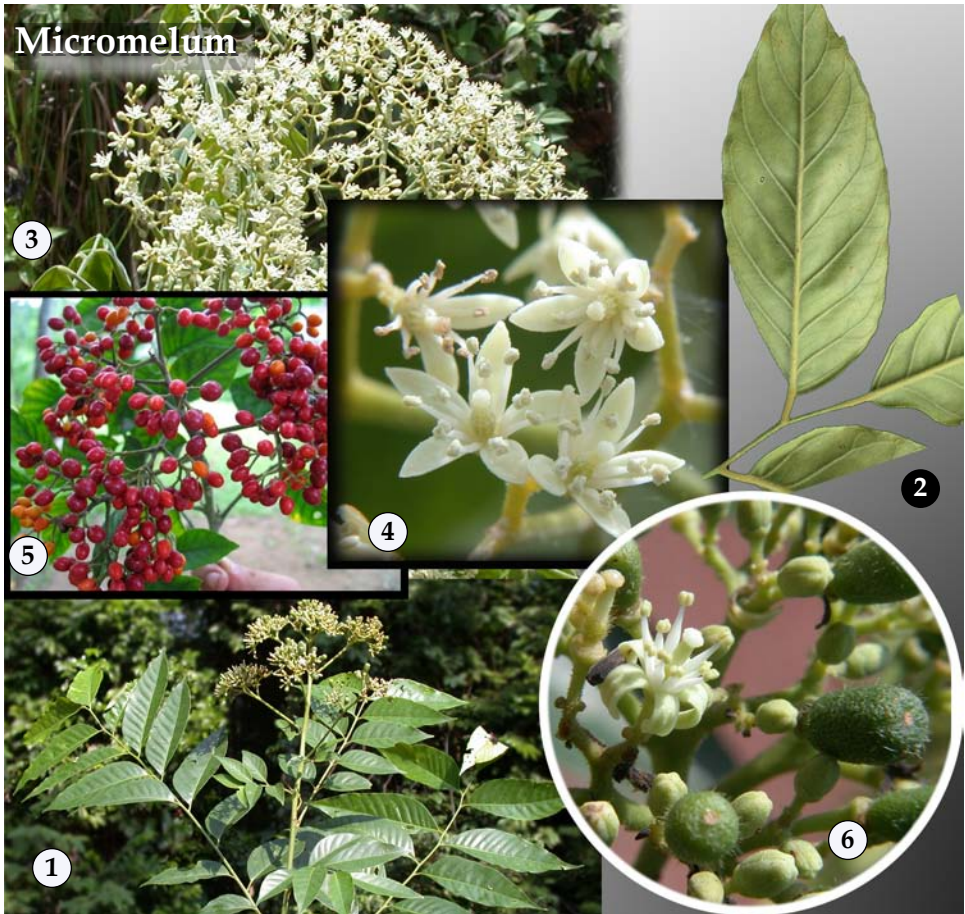
CLAUSENA. [Commemorates Peter Clausen, Danish collector, exiled army officer, died in Brazil circa 1855.] 23 species, paleotropical to Australia. Most notable is the widespread ruderal *Clausena excavata*, a small fetid shrub of forest margins, sometimes looks much like *Micromelum*, but the leaflets are usually very numerous and the petals overlap in bud. Six species are native in Philippines, plus *C. lansium*, the cultivated *wampi* from China.

MICROMELUM. [Greek, small-apple, in reference to the fruit.] Maybe 10 species from India to Australia, but especially the variable and abundant *Micromelum minutum*. The inflorescence is a broad flat-topped corymb, the petals are valvate in bud and the leaflets usually about five-seven pair. Evidently widely distributed by birds along roadsides, shores and degraded lands. One of the more common members of the family in our region, it merits a close study of ecology.

MURRAYA. [Commemorates JA Murray, d. 1791, student of Linnaeus.] 15 species from India and China to Australia, especially important tree of seasonal forests, *Murraya paniculata*, which is also widely planted as an ornamental. See But *et al.* for details on the chemical

⁹Hartley, T. 2001. Allertonia. 8: 1-328.

¹⁰But, P. *et al.* 2009. Journal of Systematics and Evolution 47: 144-150.



Micromelum minutum. one, typical habit on the roadside in Malaya; two, a leaflet of the pinnately compound leaf; three, terminal flat-topped inflorescence, rich in flowers; four, flower; five, flower and warty immature berries; six, the mature berries, red and orange. (Photograph six © Norby Bautista.)

constitution and relationships of the other species of *Muraya*.

SE Asia to the Pacific. I treat the many allied genera very briefly.

GLYCOSMIS. [Greek, sweet smelling.] Maybe 40 species, distributed from India to Australia, but most rich in the understory of lowland forest of the Sundaic Region. The leaves are mostly pinnately compound with alternate leaflets. The ecology is entirely unknown. These are small shrubs and trees, locally common and readily accessible to field studies. The genus is perfectly amenable for a field-based revision and desperately in need of a regional student.

A -- *Citrus* Group -- a

CITRUS. [Classical name for the citrons.] Uncertain species limits. (See recent molecular work by Bayer *et al.* cited in the family introduction.) Mention might only be made of *C. macroptera*, a very widely distributed native species, found at very low densities from Mainland

WENZELIA. nine species, six in New Guinea, and *Wenzelia brevipes* in southern Philippines and east.

TRIPHASIA. three species, *Triphasia trifolia*, widely Mainland SE Asia, Philippines and New Guinea. Widely cultivated in tropical and subtropical regions; *T. grandifolia* a single leaflet, known only from Mindoro, Philippines.

MERRILLIA. one, *Merrillia caloxylon*, dry seasonal tropical Asia, Mainland SE Asia to New Guinea, not Philippines.

PAMBURUS. one, *Pamburus missionis*, India, Vietnam, Java and Bali.



Murraya paniculata. On the right, a small tree, but perhaps a century in age, characteristic in habit with several branches and white shaggy bark, growing near a temple ruins in Vietnam; n the left, cultivated in the Philippines, the deep green compound leaves with bright white twigs, the white intensely fragrant flowers, the small red berry.

BURKILLANTHUS. one, *Burkillanthus malaccensis*, the type from Malacca, also collected in N Sumatra and once from Bintulu, Sarawak; three-foliolate leaves, winged rachis, large obovoid, yellow, leathery fruit.

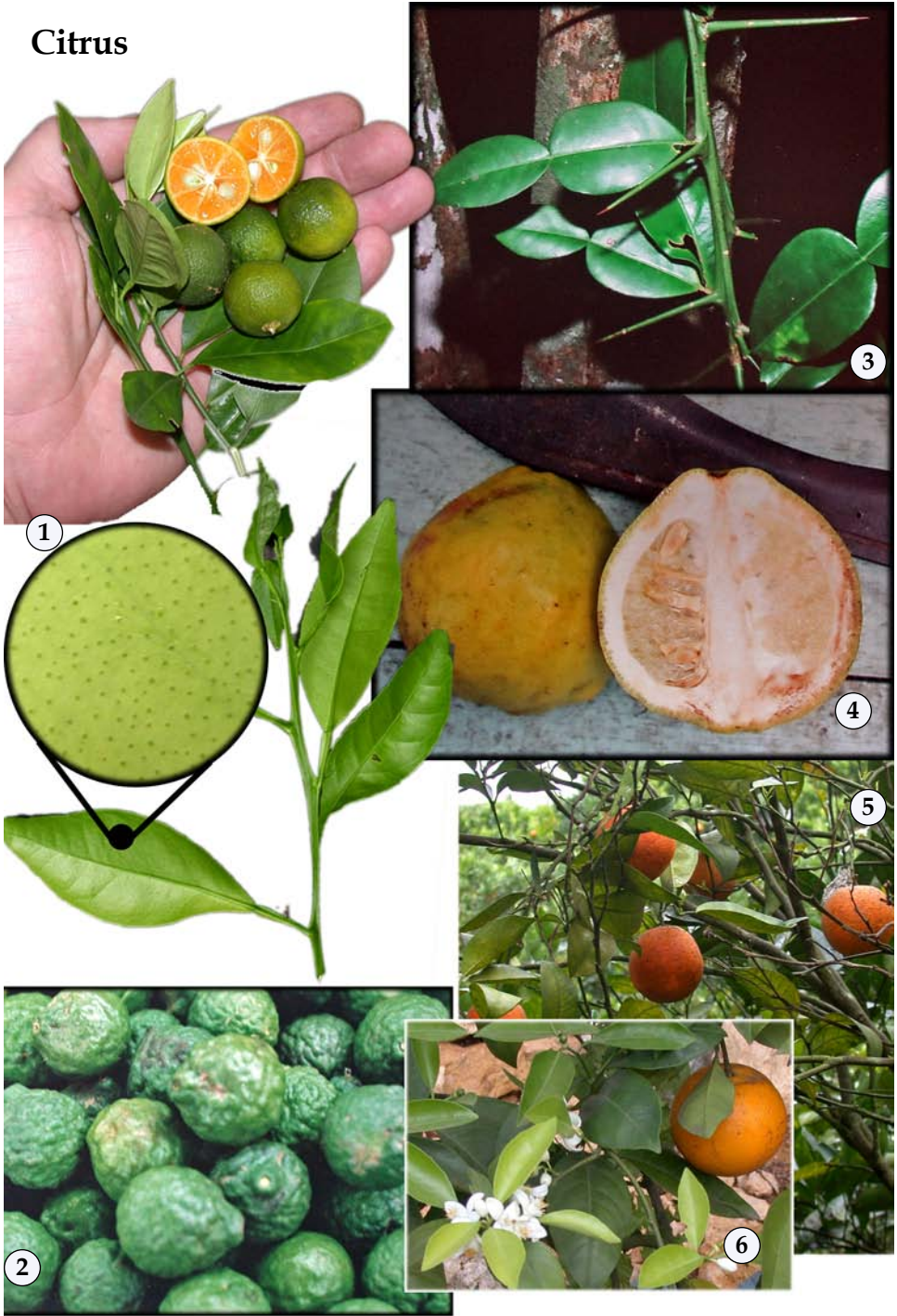
PLEIOSPERMIUM. five species, India, Sumatra, Java, Borneo, not Philippines, including former *Limnocyttus littoralis*. Also, *P. latialatum*, a fairly common small tree of roadsides on infertile soils in east Borneo, generally called *limau hantu*, or *limau butan*.

Glycosmis



Glycosmis. 1, *G. chlorosperma*, Pasoh, Malaya, leaflet pinnately compound leaf, 5 leaflets, each with venation typical of the species; 2-3, *G. greenii*, Philippines; 2, illustration showing few leaflets, yellow below, sparse fruits; 3, leaf stalk and mature fruits; 4, *G. su-perba*, Lambir, Sarawak, small shrub with thick leaflets, bright green below, and short dense inflorescence. (Illustration adapted from BLANCO *loc. cit.*; photograph 3, © Leonardo L. Co.)

Citrus



Citrus. Most of the vast number of *Citrus* cultivars are of hybrid origin, the details of their development lost to history, possibly to be recovered by molecular methods. 1, cultivated *kalamansi*, Philippines, pinnately compound leaves, the leaflet with conspicuous pellucid oil glands, the small fruit typical of the genus; 2, *C. hystrix*, the kaffir lime, market in Thailand; 3-4, *C. macroptera*, a forest tree in Huai Kha Khaeng, Thailand, with the leaves of interrupted flattened leaf stalks, axillary spines, and large pomelo-like fruit; 5-6, cultivated local varieties of citrus in the Cordillera, Luzon, Philippines.



Atalantia disticha, formerly widely known as *Severinia disticha*, a small tree not uncommon in sandy shores and secondary forests, here in Bataan, Philippines. (Photograph © Ulysses Ferrarer.)

ATALANTIA. Maybe 11 species, now including *Severinia*, tropical Asia including the Philippines & New Guinea.

AEGLE. one, *Aegle marmelos*, with large woody fruit, Indian bael fruit, native to India and Burma, culturally important, especially in Newar ritual of *ihī* or *bael byah* where premenstrual girls are ritually married to *bael* fruit as a representative of Lord Shiva. Widely but sparsely cultivated elsewhere in tropical Asia.

SWINGLEA. one, *Swinglea glutinosa*, Philippines: Luzon Island.

FERONIA. one, *Feronia elephantum*, the Indian wood apple, from India and Sri Lanka to Burma, Thailand, Indochina.

FERONIELLA. three species found in Laos, Cambodia, Vietnam, Thailand, Java.

NARINGI. [Derived, probably from Spanish for orange via a Neotropical common name.] one, *Naringi crenulata* (formerly *Hesperethusa crenulata*), Northern India, southwestern China, Thailand, Indochina.

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CORNALES

The Cornales are a small order of about 600 species and 43 genera arranged in a widely accepted molecular-based phylogeny^{1,2,3}. Despite consensus on the arrangement, the choice of which nodes to recognize as families varies among authors. Here, I follow Xiang³ except that the Mastixiaceae and Nyssaceae are combined. STEVENS *loc. cit.* also combines those families, and also the Alangiaceae and Cornaceae while dividing the Grubbiaceae. In comparison with such broad families as Malvaceae, it might be preferable to treat the 600 species as a single family. Two reasons mitigate against that option. First, the Angiosperm Phylogeny Group tries to avoid single-family orders. Second, the earliest family name would be the lesser known Loasaceae, rather than the well-known Cornaceae.

¹Xiang, Q. *et al.* 2002. *Molecular Phylogeny and Evolution*. 24: 35-57.

²Fan, C. *et al.* 2003. *American Journal of Botany*. 90: 1357-1372.

³Xiang, Q. 2005. Cornales. (unpublished pdf version at <http://www.eol.org>).

The order is heterogeneous in outward form and in chemistry (rich in iridoids, only *Alangium* with alkaloids). The inflorescence cymose and flowers generally four-merous, the calyx valvate as a tube adnate to the ovary and with more or less free lobes persistent in fruit; anthers basifixed, the ovary with a disc-like nectary near the apex, one-two apical ovules per carpel.

The Cornales are especially well-known as fossils from the Tertiary distributed widely in the Northern Hemisphere. The distribution of extant taxa includes E Asian-N America pairs and then a wide global scattering of other taxa. It is notably poor in the American tropics; the Asian tropics claim *Alangium* and *Mastixia* in the lowland forests, and a few other genera in the mountains.

The economic value of the order lies in the ornamentals, especially *Cornus* (the dogwoods) and *Hydrangea*. Other than a few traditional medicines, the chemical richness is under utilized.